POWER PLANT ENGINEERING

Established Over 35 Years

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Santa Claus Steps Out

FOR AGES AND AGES, Santa Claus has plied his trade amid the ice and snow of the North Pole. He has consistently refused to leave his frigid stronghold for more than the one night each year necessary for the distribution of the toys and gifts made during the long lonesome 364 day winter.

This winter the increasing weight of years and the comforts of civilization proved too much for the old fellow and with a bribe of a palace made from sparkling blocks of manufactured ice and lighted from the inside with colored lights, the Wisconsin Valley Electric Co. managed to get him to make a rather extended visit to Wausau during the Christmas season, while his youngest daughter was spending a month at Minneapolis. The crystal palace is shown above in all its holiday glory but Santa Claus was self-conscious and refused to pose.

We must admit that Wausau showed a great deal of initiative in building the ice palace and coaxing Santa down for a visit but secretly we must admit that we cannot see why he did not come down to some of the fine new buildings we have in Chicago. We have all kinds and shapes from the monster short and squat Merchandise Mart to the tall and thin Board of Trade topped by the equally tall, but faceless Ceres.

In order to give Santa Claus an idea of how we build in Chicago we have collected data and photographs of the more important new buildings and incorporated this in an article beginning on the next page. Of course we have no skyscrapers like New York but Chicago has always been a center of industry and transportation and it is necessary to avoid extremely tall buildings which would interfere with or endanger the fleets of commercial and tourist aeroplanes which are becoming of increased importance.

—Chicago Aerial Survey Co. Photograph

Engineering Services for Large Buildings

FOR SUPPLYING STEAM, ELECTRIC POWER, WATER, AIR CONDITIONING AND OTHER SERVICES, LARGE INSTALLATIONS OF MODERN EQUIPMENT ARE NEEDED, AS TYPIFIED BY SOME OF THE NEWER BUILDINGS IN CHICAGO

LOOKING DOWN from an airplane, the observer sees, as in the picture above, the great towers of Chicago thrusting upward from the busy streets of the downtown business district. He admires the architectural genius of the men who designed their great masses, the caisson workers who put down their foundations, the "steel birds" with clattering rivet-gun and roaring forge who assembled the mighty skeletons, the masons, carpenters, tile-setters and the myriad other artisans who clothed those skeletons, the pipe-fitters, electricians, mechanics who filled them with arteries of iron and steel pipe and nerves of copper wire and with lights and motors and a thousand and one other items.

But now these particular buildings are finished. The construction work itself was an inspiring job but it was only a means to an end—the occupancy of the buildings for the conduct of the varied office work of modern industry.

For this purpose, the engineer knows that the life-blood of any large building is its mechanical services. In such structures, the importance of fast elevator service, proper lighting and heating, telephone service, water and, in some cases, air conditioning, cannot be overestimated. A study of how this is done in the newest and largest of Chicago's buildings will repay every engineer. He will find new and interesting problems solved in original ways; he will find a tremendous quantity of mechanical equipment, all of which must function at all times at its greatest effectiveness. It is our purpose here to point out a few of the outstanding features of the equipment of several of these large buildings, with the object of showing the fundamentals of design and operation of such equipment and of stimulating further study of its details.

FEATURES OF THE WORLD'S LARGEST BUILDING

The Merchandise Mart has attracted much attention, as it is claimed to be the world's largest building. It is 18 stories high, with a tower rising six stories above the main building and contains 4,000,000 sq. ft. of floor space. All the services for a city with a permanent population of 30,000 are provided under one roof, such as a bank, restaurant, post office branch, drug store, shops and so on. The primary function of the building is to provide merchandise displays, sales quarters and offices for a great mercantile organization; these facilities occupy all floors from third to eighteenth. In the upper part of the tower is a merchants' club and convention hall and on the roof a two-story addition houses a large broadcasting studio.

To heat this building, about 200,000 sq. ft. of direct radiation is used, served by a two-pipe down-feed vacuum system. Three steam-driven vacuum pumps collect the returns, maintaining a vacuum of 10 in. in the system.

Steam for heating is generated by seven water-tube boilers fired by chain grate stokers, Fig. 4. Five boilers are of 5050 sq. ft. of heating surface each and two of 2500 sq. ft. each, all designed for operation at 160 lb. pressure but operated at 100 lb. As the building occupies the air rights over railroad tracks, coal can be brought in by drop-bottom cars and dumped directly into the coal bunkers, from which it is loaded through gates onto an elevator conveyor. The latter fills an auxiliary bunker from which a weigh larry distributes coal to the stokers. Ash is removed by discharging it direct to cars in a branch of the tunnel system that serves the entire downtown district of Chicago.

For ventilation of the 7th to 17th floors of the building, artificial ventilation is provided, with fresh-air fans on each floor at opposite ends of the building, in a single vertical line with a common riser. Exhaust fans are located on the roof. Water for the building is filtered by three 15,000-g.p.h. pressure filters. For fire protection, a sprinkler system is served by a 1500-g.p.m. motor

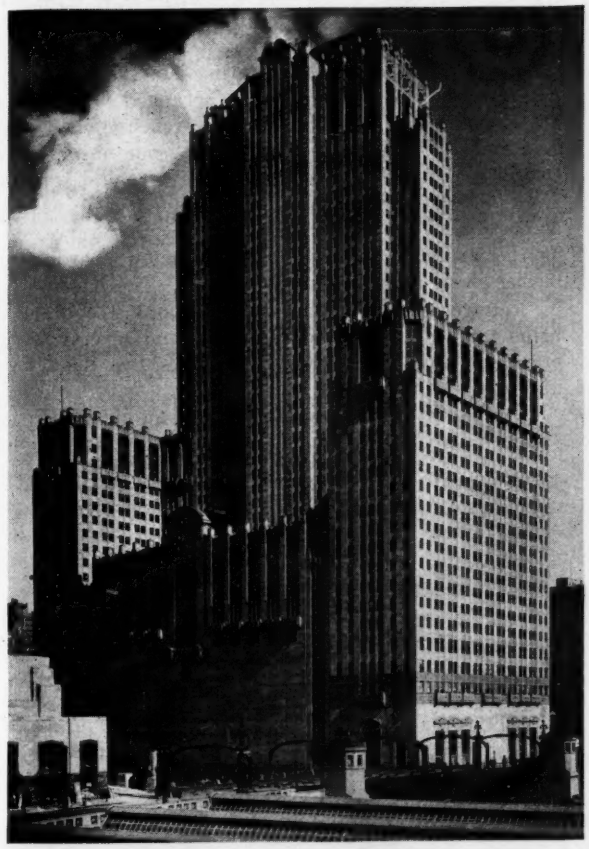
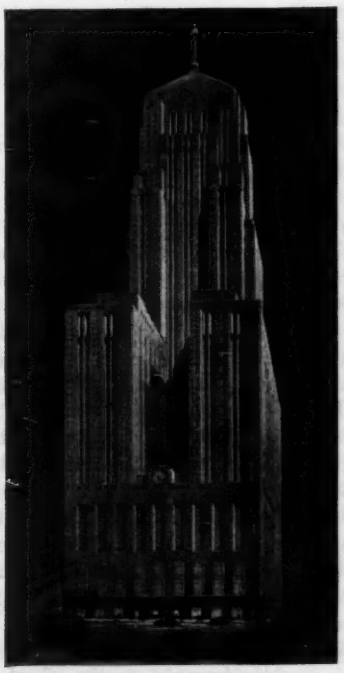


FIG. 1. A FEW OF CHICAGO'S NOTABLE BUILDINGS

Upper Left — 20 North Wacker Drive Bldg.
Lower Left — Merchandise Mart
Upper Right—Palmolive Bldg.
Lower Right — Board of Trade



driven fire pump and three 25,000-gal. gravity tanks at the top of the tower.

Passenger elevators are of the gearless traction variable voltage type, 15 elevators being installed, each designed to carry a live load of 2500 lb. at 600 ft. a minute. Besides these, two combination passenger and freight elevators and 12 freight elevators are provided.

Electric power comes into the building as alternating current at 12,000 v. to transformer vaults, where it is stepped down to 440 v. for power and 220-110 v. for

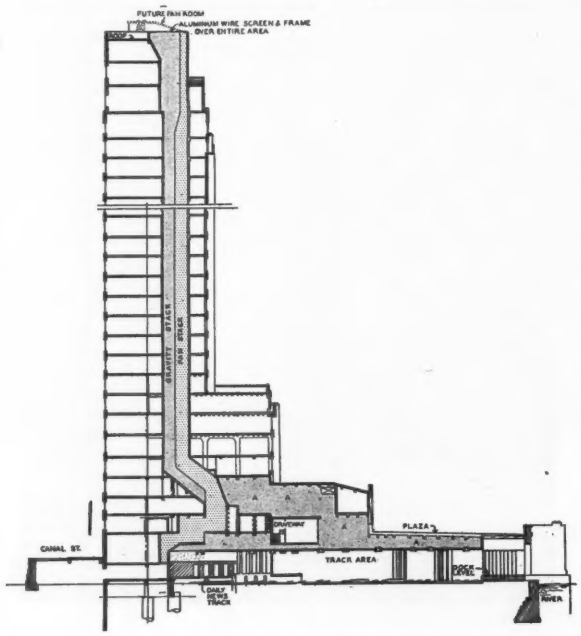


FIG. 2. SMOKE CHAMBER AND STACK IN CHICAGO DAILY NEWS BLDG.

lighting. The total connected power load is about 7000 hp. and the lighting load about 8000 kw.

Board of Trade Building

Passing from the Merchandise Mart, across the Chicago River from the north end of Chicago's Loop, to the south end of the Loop, we find the new building of the Chicago Board of Trade, Fig. 1D. This structure towers 44 stories above the street and is surmounted by a statue of Ceres. The building contains the stock exchange and main trading rooms of the Board of Trade, restaurants and shops and offices rented for general commercial purpose.

For heating this building a large amount of both direct and indirect radiating surface is installed, the latter in various air conditioning units distributed through the building. The total boiler capacity provided for heating steam is about 1600 boiler hp. in four vertical bent tube boilers, one of 350 hp., two of 389 hp. and one of 467 hp., with a smaller 150-hp. unit for summer operation. Two or three of the larger boilers operate regularly at about 200 per cent of rating during the heating season, with the other units as reserve for peak loads. The larger boilers operate at 125 lb. pressure and the small one at 100 lb. They are fired with Southern Illinois coal burned on chain grate stokers.

Coal is brought to the plant by truck and ash is removed by truck, although there is a connection with the tunnel system whereby coal and ash can be handled. Detailed description of this coal and ash-handling system was given in the Nov. 1, 1930 issue of Power Plant Engineering.

Boiler feed makeup water is taken direct from the city mains; all the returns from the heating system are collected, of course, for boiler feeding. Internal boiler treatment is employed when necessary. Drinking water flows through filters, is treated with ozone and is pumped to a pressure tank on the 15th floor whence it feeds to the system through a cooler that tempers it to 40-42 deg. F. The consumption of drinking water is not over 1000 gal. a day.

The direct radiation for heating is a vacuum system with automatic regulator control, arranged so that there are 12 zones that can be controlled from the chief engineer's office. Nine ventilating units, seven of which are complete air conditioning units, have capacities ranging from 20,000 to 38,000 c.f.m. These are located as close as possible to the parts of the building they serve, such as the restaurant, stock exchange, main board room, barber shops and so on.

Refrigeration for the air conditioning equipment, brine tank, drinking water systems and several refrigerators is supplied by CO_2 compressors, two 150-t. units and one 90-t. unit.

For operating the sewage ejectors, an air compressor supplies air at 45 lb., while another compressor supplies

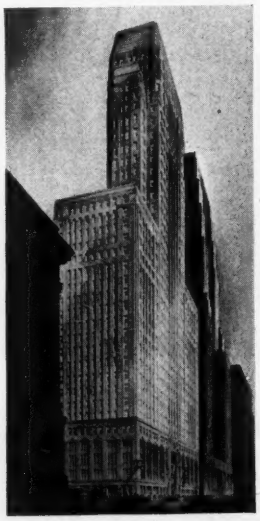


FIG. 3. FOREMAN-STATE NATIONAL BANK BLDG.

general service air for the entire building at 90 lb. for blowing motors and similar work. Vacuum cleaners, small fans, small refrigerators and other equipment of this nature are plugged into the electrical circuits at the point of use.

All electric power for the building comes from the public utility substation at 230-v. direct current and is distributed at 230 and 115 v. from a control board in the basement. Power consumption for December, 1930, was 305,000 kw-hr. A feature of the building is a low-tension 24-v. system, supplied by a storage battery, for door openers, signalling and similar services. Wiring for telephones, buzzer systems and other low tension

applications is installed in the floors in 3-compartment ducts, for ease in maintenance.

For operating the sewage ejectors, in case the compressed air fails, an emergency steam turbine of about 50-hp. capacity is installed in the sump.

Elevators are of the signal control type in three banks, including 6 tower cars, 8 express cars and 8 local cars. The maximum car speed attained is about 900 ft. a minute.

Chicago Daily News Building

Reference was made above to the fact that the Merchandise Mart occupies the air rights over railroad tracks. Another building, that of the Chicago Daily News, is also built over 12 railroad tracks handling traffic continuously. These lines are not electrified and the problem of disposing of the smoke from the engines was a serious one. Figure 2 shows how it was solved.

Smoke passes from the track space through slots in the ceiling to the smoke chamber. Several high portions of this connect to the stack and the smoke chamber is large enough to permit the gas to expand, thus preventing surges that might result from each discharge from a locomotive. The stack, with a cross-section of 380 sq. ft. is divided by a partition, forming two stacks, one designed for gravity and one for fan exhaust. The entire area, however, is used as a gravity stack, except under unusual conditions, when a small fan discharges from one corner of the track area to assist circulation. The system was designed for a maximum capacity of 195,000 c.f.m. of air. Steam for the Daily News Building is obtained from an adjacent railway station plant and electric power is purchased from the public utility company.

20 North Wacker Drive Building

Directly across the Chicago River from the Chicago Daily News Building stands the 20 North Wacker Drive Building, housing the auditorium and facilities of the Chicago Civic Opera Co., the Civic Theater and offices rented for general business purposes. The building is 45 stories high to the top of the tower shaft.

Figure 5 shows a cross-section of the boiler plant in this building. It contains three 500-hp. and two 250-hp. water tube boilers, fired by chain grate stokers; steam is purchased from a company that is operating this plant under lease. Coal can be brought to the plant either by truck or through the tunnel. In the latter case, an elevator conveyor carries the coal to a pivoted bucket conveyor, which again elevates it for discharge to coal hoppers feeding the stokers or to the coal storage bunker for reserve supply. Ash is discharged direct to tunnel cars.

FIG. 4. BOILER PLANT, MERCHANDISE MART

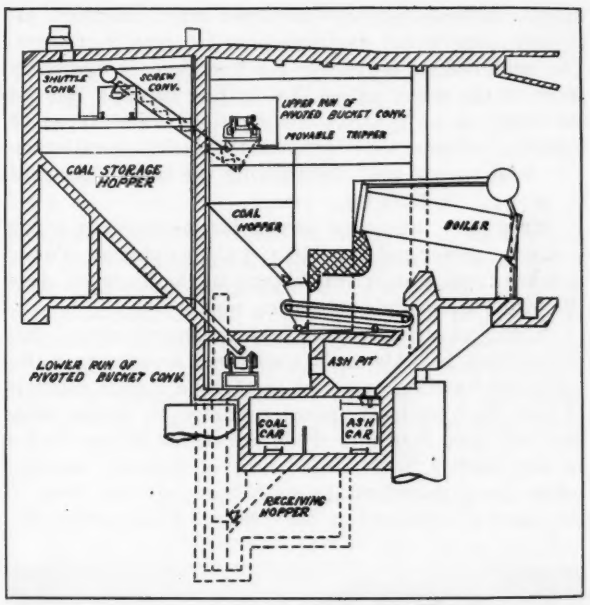


FIG. 5. CROSS-SECTION BOILER PLANT, 20 NORTH WACKER DRIVE BLDG.

In the Civic Opera Auditorium, no direct radiation is employed. Side walls are practically outside walls, since a fire escape court extends along each side. Fresh air drawn through filters is heated and discharged to the auditorium through openings in the ceiling and below first and second balconies. Exhaust air passes out through mushroom ventilators under the seats and is discharged to the atmosphere, at the top of the tower. Foyers and other auxiliary rooms are heated in the same manner. Temperature control valves and thermostats control this system. Each auditorium supply unit is arranged for future cooling apparatus to permit use of the auditorium in the summer.

Fan units with a total capacity of about 214,000 c.f.m. supply fresh air to the Civic Opera Space, using 12,790 sq. ft. of fan heater surface. Five exhaust units have a capacity of 130,700 c.f.m. The total warm air supply for the building is 360,600 c.f.m. supplied by 18 units. Some parts of the building are supplied with fresh air only, some with heated air, depending on exposure and amount of window area. The problem of heating the stage, which is 155 ft. high, with dampered openings to atmosphere at the top, was solved with direct radiation near the top. In the entire building about 133,000 sq. ft. of direct radiation is installed. The maximum heating load is about 66,500 lb. of steam an hour or about 2000 boiler horsepower.

Methods of controlling stage lighting and scenery on the stage of the Civic Opera incorporate many

unique features and have attracted much attention, although space is not available here for details of them. The main control board, for the first time, is located in front of the stage, where the lighting director can see the stage as he controls the lighting. New types of lighting controls were developed for this installation. The total energy used for lighting the stage alone will be as much as 1250 kw.

Main power and light service for the building is 220 v. d.c. for power and 220/110 v. d.c. for lighting. Power is taken from a main switchboard in the basement near the utility company's substation wall.

Electrical circuits of the building present some interesting features. Above the sixth floor, seven riser shafts serve the building; most of them have cutout cabinets at each floor for local branch circuits. To reduce cable size, not more than four floors are served by one feeder in any shaft. Each feeder runs in separate conduit, which are gathered at the sixth floor and run down to the main switchboard in one group. Tower shaft conduits continue to the basement, joining the main group there. Power conduits are carried with lighting feeders in the shafts as far as possible before being directed to local panels.

FIG. 6. CHICAGO DAILY NEWS BLDG.

Wiring in the rentable area of the building is arranged to supply separate bays and designed so that conduits can be worked on with the least cutting of building construction or interference with tenants.

Two fire protection systems are provided, each complete in itself. In the lower system, a distributing main supplies standpipes for the Civic Opera space, 12 floors high, and additional standpipes for the office portion of the building, the whole kept under 50 lb. pressure by a motor-driven automatically controlled fire pump. Connections are also made to this system for fire boats and fire apparatus in the streets. The upper system includes an automatic fire pump taking suction from the lower system pump and supplying a riser going to the 22d story, where it connects with a main supplying standpipes extending to the 45th story. Sprinkler systems for the Civic Opera and Civic Theater portions only are served by a 25,000-gal. tank under pressure at the 18th story.

General water supply is from two street mains; the water filter plant has a capacity of 60,000 g.p.h. Two water supply systems are installed, one for the floors above the 24th, the other for those below.

Elevators are arranged in three groups: a local group of 10, an express group of eight and a tower group of eight. Each has a live load capacity of 2500 lb. and the maximum speed of express cars is 700 ft. a minute.

Carbide and Carbon Building

In the Carbide and Carbon Building, all piping over 2½ in. in the heating system was welded, special valves and expansion joints being used so they could be welded in. Dirt traps on radiators were also used to minimize trap and valve maintenance. A vacuum system supplies steam usually at below atmospheric pressure to the direct radiation and at boiler pressure to blast heaters and hot-water heaters. Direct radiation is in two zones, one of 7500 sq. ft. for the tower and one of 30,000 sq. ft. for lower floors. Each zone has its own vacuum pump with control equipment to maintain differential of 2 in. of mercury automatically between supply and return systems. Heat emission per square foot of radiation is varied to correspond with heat losses of the building by thermostatically-controlled motor-operated valves. Steam is supplied by two 300-hp. boilers designed for 100 lb. pressure, with a 75-hp. boiler for hot water. Offices of the Union Carbide & Carbon Corp. are served with conditioned air. Fan equipment, humidifying apparatus, tempering coils and filters occupy a portion of the 24th floor. These are automatically controlled by temperature and humidity controllers.

From the foregoing data, it is apparent that the engineering and general mechanical services of large buildings demands a high degree of skill in design and operation. Steam loads requiring 2000 to 3000 boiler horsepower are not uncommon, connected power and lighting loads of 3000 to 5000 kw. are noted, great banks of elevators traveling at from 600 to 900 ft. a minute carry people up into the building, fans of 20,000 to 30,000 c.f.m. capacity supply air to them. The problem of fire protection and water supply in a 45-story building is a large one in itself. Piping and electrical circuits must be designed so that equal distribution in all parts of the building is secured without undue cost of material. All possible conveniences must be supplied to the tenant. Then, after all this equipment is installed, it must be kept in operation by a skilled engineer.

This is the problem of the skyscraper that is of most interest to our readers today. Its social implications, its relation to traffic, its desirability from the standpoint of space values and many other questions we cannot discuss here. As a form of art, it is worth much study. New uses of metals, new forms of massing and fenestration, new uses of color, the "painting" of the structure at night by floodlighting—all these merit attention. Our present purpose, however, is to point out that the modern skyscraper has become in a few short years a structure filled with engineering equipment of a size and complexity comparable with that of many industrial plants. Thus, entirely apart from its aesthetic or social significance, the modern skyscraper is becoming an interesting and vital factor in the field of power engineering.

Air Preheating and Plant Economy

HIGHER LIMITS TO BE USED WITH LOWER GAS EXIT TEMPERATURES AND SIMPLER DUCT ARRANGEMENT. BY R. C. ROE*

POWER PLANT economy and power plant cost have shown increasingly the effect of air heating in recent years. Various types of air heaters, that is, plate, tubular type and regenerative type, all have their opponents and advocates and all have users whose trend is toward each particular type and perhaps uses to which each particular type is best adapted.

In modern boiler practice it has been possible to obtain high overall efficiencies for a portion of which the air heater is responsible but it should not be thought that, because these comparatively high efficiencies have been obtained, the ultimate in boiler plant design or the ultimate in boiler plant efficiency has been reached. In fact, it is believed that the contrary is true and that we must continuously strive for better efficiencies, greater simplicity and lowered first cost.

PREHEATED AIR FOR STOKERS

Designers of power plants have had some hesitancy in the application of preheated air to stoker fired installations, this hesitancy in some respects being caused by lack of data or knowledge as to the effect of preheated air on the stokers. It is believed that this hesitancy has, in many cases, been unwarranted and that preheated air should be more favorably considered for stoker plants. A number of installations have been made with various types of stokers, both in new stations and in stations being rehabilitated and the hesitancy which previously has been apparent is largely disappearing as the results from the installations which have been made have become better known and the inertia of past practice is thereby overcome.

When working on this problem the designer should consider carefully the probable effect of air temperatures on his stokers, the method of the construction of the stokers, allowance for expansion of stoker parts and keep the temperatures applied to the stokers within such limits as represent a safe and sound practice when applied to other equipment subject to similar temperatures. In many cases, the stoker manufacturer can and will give valuable assistance in this phase of the problem and the designer should not be unduly skeptical about the use of preheated air in these conditions. If he bears in mind sound engineering in regard to materials and expansion of materials with which he is working, he is unlikely to get into serious trouble. In some cases where fuels are being used which tend to become viscous when heated, it is desirable to consider this fact also. The use of these coals on stokers, however, is the exception and not the rule, hence this phase of the problem is seldom encountered.

On practically all types of stokers the effect of preheated air on the combustion is favorable and has a distinct tendency not only to increase efficiency due to heat recovery in the preheated air but also to increase efficiency due to the better combustion conditions which it is possible to obtain and the increased ease with which these combustion conditions can be obtained. It is felt that this point is one which, while it is impossible to evaluate it actually in dollars and cents is nevertheless of importance. It is quite easy to design the equipment in power plants to give good efficiency but the actual efficiency in practice is dependent quite as much upon the ease with which it is obtained as it is upon the possibility of obtaining it. Anything done to make higher continuous efficiencies easy to obtain in operating practice will be amply repaid in the overall results secured in regular operation.

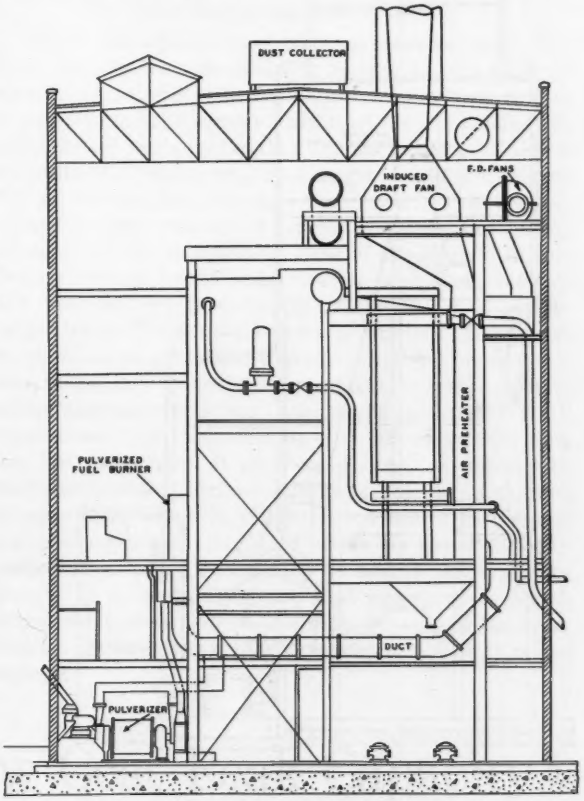


FIG. 1. PREHEATED AIR DUCT AT SOUTH AMBOY IS SHORT AND DIRECT

PULVERIZED FUEL PLANTS

In pulverized fuel installations, great progress has been made in the use of preheated air. The present tendency seems to be for increasing temperatures and this points towards one of the best methods of improving furnace conditions and possibly of ultimately reducing furnace volumes and lowering initial cost of the completed boiler plant.

In considering high preheated air temperatures, the

*Electric Management and Engineering Corporation.

primary and secondary air temperatures should be considered separately. In many cases limits are definite beyond which the primary air temperatures cannot be safely used. It is believed that the time has come when secondary air temperatures should depart from the limitations of primary air temperatures and should be increased materially. Subject to proper materials in the ducts, wind boxes, burners and air heaters, there is no reason to set any particular top limits for secondary air temperatures. The problem presented by the design of air heaters for these high temperatures, however, is one of some difficulty and the possible use of metals and

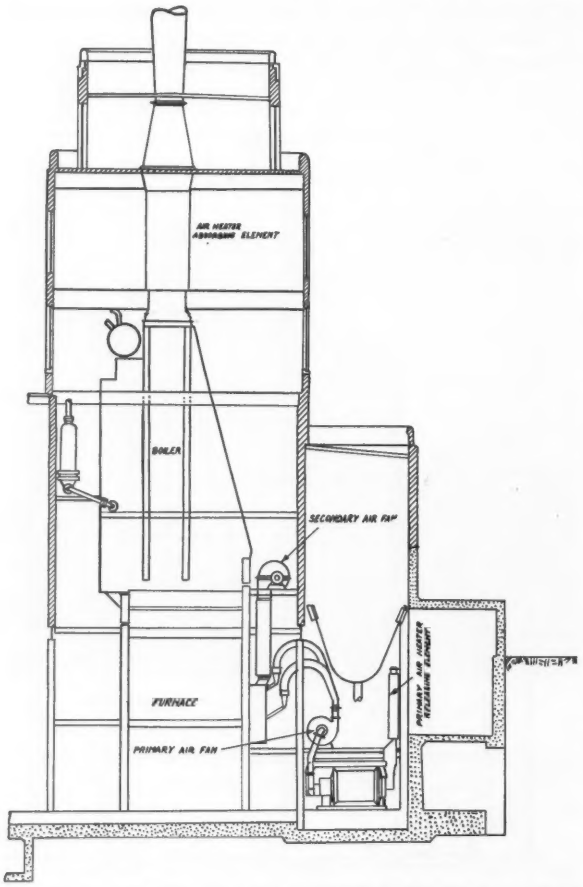


FIG. 2. BREMO BLUFF USES DIPHENYL-OXIDE FOR HEAT CARRIER FROM FLUE GAS TO AIR

alloys suitable for high temperatures in the high temperature zones of air heaters should be more generally considered just as fast as they are proven to be practical and safe and as fast as economics permit. It is the writer's belief that this would result in a ready solution of the problem of higher air temperatures and the consequent betterment of furnace conditions.

In the matter of primary air in pulverized fuel installations, investigations should be made of the probable coals used in the station and determinations should be made of their characteristics when subject to preheated air or heat for the length of time they will be so subjected as they pass through the pulverizer, thence to the fire, paying particular attention to points where volatilization begins, the character of volatilization and its effect on fuel structure. When these investigations are made, the same quantities of air should be used in proportion to the quantity of coal with the coal at its normal or at least its minimum moisture content. Moisture content has a distinct bearing on the amount of preheat which must be imparted to the primary air, inasmuch as this moisture must be evaporated and to do this takes up heat from the air.

Results of such an investigation will usually indicate the limits of temperature that may be used in the pulverizer and for transport, after which due allowance should be made for a reasonable factor of safety. These safe limits will be usually higher than would be chosen, if the designing engineer merely used his judgment and the opinions of other engineers. It will often be found that the degree of distillation of coal in contact with air at high temperature is negligible and produces no detrimental effect on the coal structure for the pulverizer; in fact, up to proper limits it is well recognized that preheated air is an important factor in increasing the pulverizing capacity of given pulverizing equipment, particularly with coals of high moisture content.

Exit Gas Temperature

Tendency to maintain the exit gas temperature in air heaters at all times above the dew point is at the present time a proper and safe one, but it is believed that, in the future, it will be possible to design air heaters of non-corrosive alloys in the last sections, so that this precaution will be unnecessary. The exit gas will then be brought down not only to the dew point temperature but a portion of the condensable vapors in the gas will be deliberately condensed and an important advance made in the improvement of overall efficiency by the recovery of all or a portion of the latent heat in the condensable gases leaving the air preheater. We would point out that this is a field which will probably be more profitable even than appears on the surface and perhaps merely needs a non-corrosive material of low enough first cost to come into general use. Along with this lowered exit temperature, there would perhaps necessarily have to be provided new cleaning methods for the surfaces subjected to such temperatures.

Duct Layout Is Important

One factor which is often considered insufficiently is the cost and layout of duct work and duct work insulation. This is a matter which should receive careful consideration because these are expensive and their layout often involves intricate problems. The resultant cost often reaches a large proportion of the total preheating air cost, consequently this equipment should be given careful thought in layout and in determining the economics of the air heater installations. Many times, the location of the air heater can be so arranged as to minimize the duct work and this, when it can be done, is desirable. The matter of proper supporting and adequate means for expansion should not be overlooked. The matter of dampers, particularly dampers adjacent to the burners and in some cases to the fans is one that is seldom given enough attention. Dampers as at present installed are in many cases rather crude, have too much clearance, are improperly balanced and no attempt is made to have them absolutely air tight when closed. In some recent installations, this matter has been

given consideration to the extent of installing asbestos or felt facings for damper leaves, providing machined surfaces for these faces to rest upon when the dampers are closed and otherwise making an earnest endeavor to build dampers which will be air tight and will not leak air backwards through the idle fans or let air pass inward through idle pulverized fuel burners when this is undesirable.

One good example of the arrangement of air heaters to shorten duct work is incorporated in the South Amboy Station of the Jersey Central Power and Light Co. where a tubular air heater is installed in such a position that the air outlet is near the bottom of the boiler, not the top, and the duct work leads from this low air outlet directly under the boilers to the burners and pulverizers, see Fig. 1.

Liquids for Heat Transfer

One of the newer developments in air heating is the so-called diphenyl air heater. These air heaters have a heat absorbing section in the gas path of the boiler, after the boiler or economizer, and a number of heat releasing sections in the individual burners and pulverizers of the same boiler. The heat is conveyed by the circulation of a heat conveying liquid, which can be diphenyl, diphenyl-oxide or mixtures of other substances with these substances; by this method all the duct work, or at least the major portion of it, is omitted. This permits a saving of space and gives great flexibility in operation of the boiler. This type of air heater requires more surface for a given amount of air heating than do other types but in some cases the elimination of duct work and the space saving by this elimination will warrant its use. In this type of air heater, the heat to primary and secondary air can be accurately proportioned in accordance with fuel requirements and this type of air heater lends itself well within a limited range to higher air temperatures, that is up to around 800 deg. secondary air temperature or perhaps slightly more. The absorbing element in this type of air heater can be made with cast iron or other protective surfaces, which is desirable from a corrosion viewpoint. This air heater would lend itself well to constructions which would permit low exit temperatures.

Illustration of a diphenyl-oxide air heater is shown herewith, as made in the plant of the Virginia Public Service Co. at Bremo Bluff, Va., Fig. 2. In this particular plant an effort was made to simplify the boiler room layout by the construction of a vertical single pass boiler without baffles and a straight gas path from the furnace directly through the boiler and the absorbing element of the air heater to the stack. The duct work with this high type of boiler would necessarily be long and therefore expensive but height is not an objection for the type of air heater used because duct work is largely eliminated. Both the stations mentioned are good examples of preheater air installations with minimum installation duct costs.

Bled Steam for Air Heating

Some installations have been made where steam bled from the turbine was used for heating air for the furnace. We believe these installations have been few in number as most designers have used bled steam for the regenerative cycle rather than for air heating. There is no particular reason why bled steam should not be used for air heating purposes and the proportion of heat regained by this practice of course would depend on the efficiency of the boiler unit. Most of the steam available for air heating from bleeder sources is at comparatively low temperature; therefore the temperature of air obtained from this source is usually limited. It appears to be the opinion of most engineers that it is more desirable to use this steam in the regenerative cycle and heat boiler feedwater this way, also sometimes with a small economizer, then heat the air with an air heater from the flue gases, than it is to use the colder water with more economizer surface and heat the air with bled steam. Many times it will be found nearly as economical and sometimes more so to install air heater capacity rather than added economizer or added height in the boilers, as it is often the case that increment cost with larger air heaters will be less than the cost of the economizer or the portion of the economizer that it might replace.

Bleeder Turbines for Low Cost Peak Capacity*

Hot Feedwater Storage at Low Load to Reduce Overhead and Heat Per Total Kw-Hr. Output. By A. G. Christie[1] and Warren Viessmann[2]

CENTRAL STATION management has always been confronted with the problems of large plant investments to meet maximum demands and with low use factors due to peak loads. The problem of supplying peak load capacity at minimum cost has been attacked more or less successfully and solved by various methods.

Professor Christie discussed briefly the use of obsolete plants as peak capacity, of hydraulic storage, of Diesel engines as standby power, of steam accumulators, of refrigerated generator cooling and of heated air circulation around the turbine casing to keep the unit up to starting temperature at all times. Each method has advantages, according to circumstances but has also its limitations.

Bleeder Type Control

In this country, bleeder type units for heating the feedwater, give high temperature feedwater economically but the turbo-generator capacity is reduced below that possible with complete expansion and with the same steam flow entering the turbine. This suggests that increased turbo-generator output might be obtained by shutting off the bleeder heaters and permitting the total steam flow to pass through the whole turbine to the condenser. That such power is available and can be obtained, has been demonstrated by trials made at Gould

*From a paper before the New York Section, A.S.M.E.

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St. Station, Baltimore, Long Beach Station, Los Angeles, and Lakeside Station, Milwaukee, where trials indicated that capacity for short peaks could be obtained by this method.

By shutting off the bleeder heaters, colder feedwater must be supplied to the boilers and, when all heaters are cut off, this feed will be at condensate temperature. This increases the heat per pound that must be supplied by the boiler, hence the rate of firing; also furnishing cold feedwater increases stresses in feed lines and in boiler shells. If, however, there is no objection to cold feedwater and to further loading the boiler and furnace, substantial increases in peak load capacity can be obtained by shutting off the bleeder heaters.

These considerations indicate that any method which can be developed to discontinue bleeder feedwater heating at the time of peak loads of relatively short duration, without at the same time necessitating the use of cold feedwater for boilers, deserves careful consideration.

All Peak Load Bleeding Eliminated

Diagrammatic arrangement of such plant equipment is shown in Fig. 1. A modern turbine is provided with

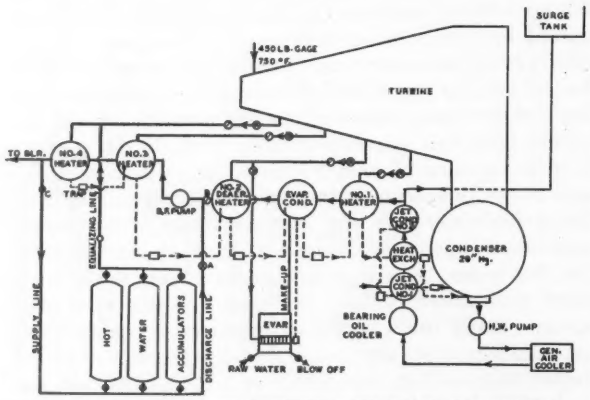


FIG. 1. FEEDWATER STORED AFTER NO. 4 HEATER

the following auxiliaries, four bleeder heaters one of which is closed-tube deaerator heater, a one-stage evaporator with evaporator condenser, a heat exchanger, two jet condensers for the vacuum jet air pumps, a bearing oil cooler and a generator air cooler. Full capacity of the turbo-generator set with this equipment in service was assumed to be approximately 62,000 kw., when operating at 450 lb. gage steam pressure, 750 deg. F. steam temperature, 29 in. of vacuum with boiler feedwater heated to 386.8 deg. F. when leaving the last bleeder heater and when 673,000 lb. of steam per hr. is entering the throttle. Hot water accumulators, surge tanks of increased capacity and some additional valves and piping are the only equipment added to this standard layout to enable it to carry peak loads with all bleeder heaters out of service, the boilers being furnished with hot feedwater from storage.

During periods of load in excess of nominal maximum capacity when bleeding, extraction of steam to the four heaters is discontinued and the condensate, after passing through the generator air cooler, bearing oil cooler, No. 1 jet condenser, the heat exchanger and No. 2 jet condenser, is stored in the surge tank. Feedwater for the boilers at about 365 deg. F. is furnished from the hot water accumulators, a small amount of steam being automatically supplied from No. 4 bleeder heater connection to the hot water accumulator to compensate for the displacement of the hot water drawn off by the boiler feed pump and to maintain pressure in the accumulators. Normally these accumulator tanks should be full of water and in continuous contact with and circulated by steam from this fourth bleeder point when heavy loads are expected. The water in the accumulators, therefore, has approximately the same temperature as the steam from No. 4 bleeder.

To demonstrate the operation of the proposed system, assume that the accumulators are filled with hot water at the temperature of the fourth bleeder heater and that the load is approaching the maximum capacity with all four bleeders in operation. Discharge valve A from the accumulators to the boiler feed pump suction is opened. Since water pressure in the accumulator exceeds that from the condensate pump at the inlet to the boiler feed pump, the check valve B on the regular feed line closes automatically. As feedwater from the accumulators leaves the boiler feed pump and passes through the third and fourth bleeder heaters at the temperature at which it normally leaves the fourth bleeder heater, no steam is drawn from the turbine shell by these two heaters, which act as if they were cut off from the turbine. Steam normally withdrawn at these two points now passes through the turbine to the condenser, increasing substantially the available energy to do work.

When check valve B closes, flow from the condensate pump can no longer pass through the first and second bleeder heaters but goes directly to the surge tank. With no water flowing through these heaters, no steam is withdrawn at the corresponding bleeder points and the heaters are virtually cut off from the turbine. Steam that would normally be bled by them passes to the condenser, adding further available energy to that provided by the steam not now required in the third and fourth heaters. Increase in output is substantial, even after allowance is made for increased leaving losses and for decrease in condenser vacuum, the flow of cooling water being maintained constant.

Operation requires only opening valve A. All other events are automatic and it is even possible to provide a control which will automatically open valve A when the generator load, or as an alternative certain stage pressure, reaches a predetermined amount.

When load falls below full capacity, bled steam to the four heaters is utilized to heat, not only the condensate from the condenser at that load but also a portion of the condensate which was stored in the surge tank during peak load period. This excess of hot water above boiler feed requirements is utilized in charging or refilling the hot water accumulators, the rate of heating being adjusted by valve C so that sufficient steam is bled during this charging period to place an efficient load on the boiler plant and also so that the turbine operates at approximately its most economical rating. Other charging rates could, of course, be utilized, if necessary.

Thus, with the addition to a standard, modern installation of a few insulated tanks, piping and valves for hot water storage, an enlarged surge tank and the utilization of generator reserve capacity, either provided at

the time of installation or, if necessary, by supplementary generator air cooling, a simple method of obtaining peak load capacity for short periods is secured with minimum equipment.

Heat balance calculations have been made for such a four-bleeder heater installation having maximum output of 62,040 kw. and most economical loading of 51,150 kw., with all bleeders in normal service under operating conditions of 450 lb. gage, 750 deg. F. and 29 in. vacuum, 386.8 deg. F., feedwater temperature from heaters, at maximum load. Air preheating to 400 deg. F., with forced and induced draft fans, was assumed, using powdered coal in a boiler plant consisting of three boilers each of 23,000 sq. ft. of heating surface, operating at 84 per cent efficiency, when delivering the maximum steam required. The power requirements of circulating, hotwell and boiler feed pumps, coal preparation for powdered fuel, vacuum pump for deaerator, evaporator pump, transformer oil cooling, service water pump, forced and induced draft fans and miscellaneous intermittent service were computed. The net station output at maximum capacity is 57,630 kw. and, at most economical load, 48,200 kw. after allowing for all station auxiliary requirements. Net maximum station output could be increased by the use of hot-water accumulators, as outlined above, from 57,630 kw. to 67,825 kw., a gain in capacity of 10,195 kw., or 17.7 per cent.

Table I gives the various capacities and station heat rates for normal operation without accumulators, and for operation on peak loads with accumulators designed for 2-hr. peaks of rectangular form. The accumulator was assumed to be recharged over an 8-hr. period, four times as long as that of discharge. Two performance figures in B.t.u. per kw-hr. are given for accumulator discharge conditions. The first figure represents the actual performance during the peak load period when the boilers receive stored hot water from the accumulators. The second figure marked "compensated station performance for accumulators discharging, B.t.u. per kw-hr." indicates the station rate during peak load with the accumulators discharging but with calculated allowances included for the heat required from extra steam bled to heat the water from the surge tank during the charging periods of the accumulators. These calculations involved the determination of the total station heat consumption under a variety of loads with and without charging of the accumulators.

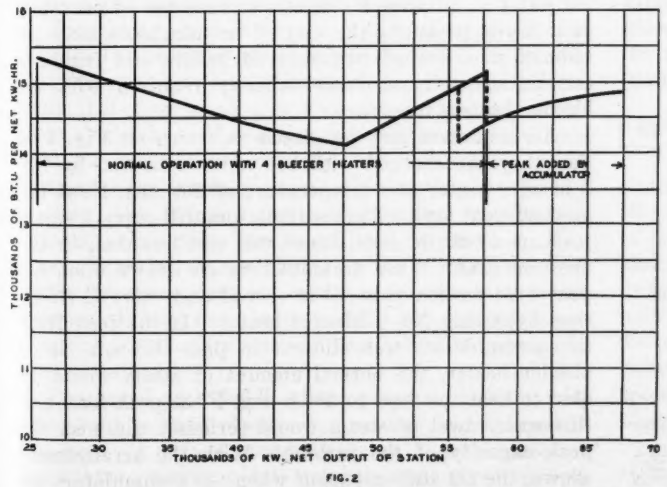
TABLE I. EFFECT OF FEEDWATER STORAGE

Normal Operation				
Net station output, kw....	57,630	48,200	36,900	25,060
Overall station performance B.t.u. per kw-hr.....	15,130	14,150	14,750	15,330
Accumulator Discharge				
Net station output, kw....	67,825	61,655	57,645	55,800
Overall station performance with accumulators discharging, B.t.u. per kw-hr.	12,900	12,770	12,470	12,210
Compensated station performance for accumulators discharging, B.t.u. per kw-hr.	14,875	14,695	14,385	14,120

In Fig. 2 is given the performance curve of the station for normal operation and for operation with the accumulators discharging on peak loads. The equipment is flexible, so that any variety of peak or sustained load can be handled successfully for the length of time for which the accumulators are designed. Naturally the total duration of the peak load that may be carried, is governed by the storage capacity of the accumulators. For a 2-hr. peak, three accumulators of 8480 cu. ft. capacity each have been provided for this plant. They would be 12 ft. in diameter, with hemispherical ends, and 80 ft. long. They are of sufficient size to store the 1,366,000 lb. of feedwater required for operation of the plant at full peak load capacity for 2 hr. These accumulators were estimated for installation out-of-doors with 5 in. of insulation and with an outside sheet metal covering. Increased surge tank capacity of approximately 22,000 cu. ft. was assumed to be provided within the plant.

Plant Costs

To provide this capacity, Table II gives figures believed to represent substantially actual costs.


THOUSANDS OF B.T.U. PER NET KW-HR.
NORMAL OPERATION WITH 4 BLEEDER HEATERS
PEAK ADDED BY ACCUMULATOR
THOUSANDS OF KW. NET OUTPUT OF STATION
FIG. 2

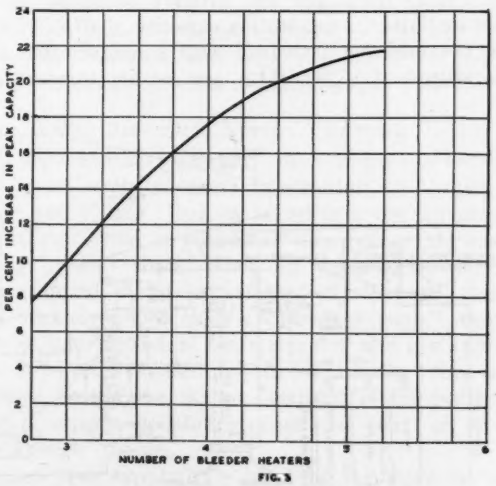


FIG. 2. STATION HEAT RATE AS AFFECTED BY FEEDWATER STORAGE

FIG. 3. EFFECT OF NUMBER OF HEATERS ON GAIN IN PEAK LOAD CAPACITY, WITH FEEDWATER ACCUMULATOR STORAGE

TABLE II. ADDED PLANT COST WITH ACCUMULATORS

3 accumulators, each of 8480 cu. ft. capacity	$110,000
Foundations for accumulators	15,000
Insulation for accumulators	10,000
Additional valves, piping, and pipe covering	15,000
Cost of enlarged surge tank	16,000
Cost of 10,000 kw. of increased generator capacity and cooling system at $5 per kw	50,000
Engineering and overhead expenses at 15 per cent	32,400
Total	$248,400

For increase in maximum capacity of 10,195 kw., the plant cost is $24.36 per kw. of added peak capacity which may be compared with $90 to $100 per kw., the average cost of standard plant in modern stations of the size here considered.

For a continuous, sustained peak of less than 67,825 kw. for 2 hr., smaller accumulators could be used and the investment cost would be decreased. If peak loads last longer than 2 hr., more or larger accumulators would be needed at an added cost.

Effect of Number of Heaters

Calculations have been made for a plant of similar capacity and arrangement, assuming the same maximum throttle flow of steam but with five bleeder heaters, producing a final feedwater temperature of 403 deg. F. instead of 386.8 deg. F. at maximum load. With the addition of the fifth heater, 56,595 kw. net station output could be obtained as the maximum normal loading with a heat rate of 15,200 B.t.u. With the accumulator on discharge, a net station load of 68,620 kw. could be carried at the time of peak load with a compensated heat expenditure of 14,820 B.t.u. With the fifth heater installation, an increase of 12,025 kw. or 21.25 per cent in net station capacity will be obtained in the peak load that can be carried, above the possible without accumulator storage.

For a similar plant provided with only three bleeder heaters, the feedwater would be heated to 317.1 deg. F. at maximum load. Maximum net station output of 61,730 kw. would be obtained with a heat expenditure of 15,130 B.t.u. per kw. without accumulators. With accumulators, a net station capacity of 67,970 kw. could be obtained for peak load with a compensated heat expenditure of 15,060 B.t.u. per kw-hr., increase of 6240 kw. or 10.1 per cent in the peak capacity by the use of accumulators.

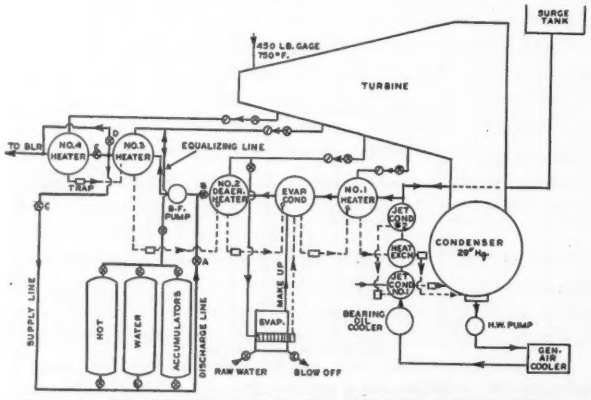


FIG. 4. FEEDWATER MAY BE STORED AFTER NO. 3 HEATER

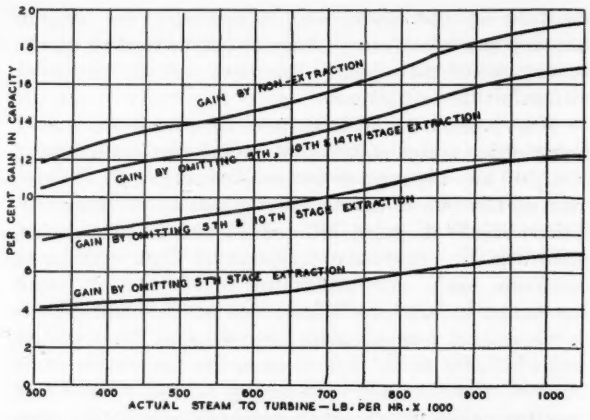

PER CENT GAIN IN CAPACITY
GAIN BY NON-EXTRACTION
GAIN BY OMITTING 8TH, 10TH & 14TH STAGE EXTRACTION
GAIN BY OMITTING 5TH & 10TH STAGE EXTRACTION
GAIN BY OMITTING 5TH STAGE EXTRACTION
ACTUAL STEAM TO TURBINE — LB. PER HR. X 1000

FIG. 5. GAIN IN TURBINE CAPACITY BY CUTTING OFF BLEEDER HEATERS

In each case, the economies of operation, including all radiation and heat losses, are substantially as good with the accumulator, after allowing for recharging the accumulator, as they would be without the accumulator installation. Figure 3 shows the relation of peak load to number of heaters used, these gains being secured with no increase of boiler or furnace outputs over those with all bleeders in operation.

As to the number of bleeder heaters to be used, justification of the last heater depends upon the fuel saving as represented by the improved heat rate, compared to the fixed and operating costs of the heater. With the utilization of hot-water storage, it is probable that an additional heater may be warranted on the basis of the additional low-cost peak-load capacity that may be secured through its use. In new station designs, it is quite probable that the use of five bleeder heaters in conjunction with hot-water accumulators will be employed to an increasing extent to provide such low-cost peak capacity.

Other Methods of Water Storage

For four bleeder heaters as considered, accumulators must be built for a steam pressure of 215 lb. to store hot water at 365 deg. F. If this storage can be provided at a lower pressure, the cost of accumulators may be reduced in either of two ways, if boilers and furnaces can be loaded beyond the capacity required with all bleeder heaters in service.

Accumulators may be placed as shown on Fig. 4 so that they are charged with hot water delivered by No. 3 bleeder heater at a temperature of 299 deg. F. at the most efficient load. The accumulators will carry a steam pressure of 80 lb. gage, hence will cost less than in the previous case. When accumulators are drawn upon for peak load service, valve D is opened and valve E closed thus bypassing No. 4 bleeder heater. If the feed from the accumulators was allowed to pass through No. 4 bleeder heater, the normal amount of steam would be bled to heat the feed to 386.8 deg. F. at peak load and this withdrawal of steam would seriously diminish the peak capacity of the turbine. With the arrangement shown, the net station output when the accumulators are discharging would be about 67,700 kw., an increase of 17.5 per cent over full bleed conditions. Accumulator

water will pass to the boiler at 299 deg. F., requiring an increase of boiler output and of fuel burned of approximately 8.6 per cent.

Storage of hot water after No. 2 bleeder heater is possible at a still lower first cost, with a large hot well reserve between the second bleeder heater and the boiler feed pump. Water is stored at an average feed temperature, at most efficient load, of 232 deg. F. Steam pressure on the tank will be 18.7 lb. per sq. in. gage, hence comparatively light weight receivers can be provided, at lower cost than any of the other accumulator schemes, also a further saving in valves and piping. Net station output at maximum capacity with the accumulator discharging would be about 67,670 kw. or an increase of 17.4 per cent over maximum capacity with all bleeders in service. Feedwater passes to the boiler at about 232 deg. F., which would require an addition of 15.4 per cent to the boiler capacity and to the coal burned. This, however, is not a serious consideration for, if it is assumed that the boilers operate at 304 per cent rating with full capacity of 57,630 kw. when all four bleeders are in service, they will now be operated at 352 per cent rating at maximum peak load of 67,670 kw. with water storage after No. 2 heater. Peak loads are assumed to be of short duration, hence this increased output of boilers is not excessive.

In all three methods, the gain in peak load capacity is substantially the same, i.e. 17.5 per cent. Boilers and furnaces, however, operate at the same output with or without accumulators in service when placed at No. 4 bleeder heater but at increased output in the other positions.

When boilers can be operated at high ratings with water colder than normal, peak load capacity can be increased as already indicated by simply cutting off the bleeder heaters and feeding the condensate directly to the boiler. Additional generator capacity must be installed or some method of refrigeration generator cooling used.

By cutting off No. 4 bleeder heater, only, computations indicate that the peak load capacity will be increased about 6 per cent, while the boiler output and fuel consumption will be increased about 7 per cent. If both No. 4 and No. 3 bleeder heaters are cut off, the peak load capacity will be increased about 11.8 per cent with an increase of boiler output of approximately 14 per cent.

Additional data on the gains in turbine capacity that may be secured by cutting off bleeder heaters is shown in curves of Fig. 5 presented in the recent N.E.L.A. report on turbines from tests on a 94,000-kw. General Electric turbo-generator with four bleeder heaters and operating at 400 lb. gage pressure, 725 deg. F., and 28.5 in. vacuum. Per cent gain in capacity shown on these curves refers to the turbo-generator capacity only, not to the net station output as is the case in figures previously given.

These methods give substantial increases in peak load capacity at a small sacrifice in station economy and their use involves no additional cost, if the generator can carry the added load. Additional cooling in the generator will be inexpensive. Such methods can be used advantageously at the time of peak load in almost any modern plant with three or more bleeder heaters.

High Pressure Pays

RELIABLE CONTROL OF WATER AND HEAT SUPPLY, WATER FREE OF OXYGEN, PROPER OPERATION ROUTINE ARE ESSENTIAL. BY M. K. DREWRY*

AT A RECENT national technical meeting a showing of hands was asked indicating organizations that were planning new 1200-lb. and 600-lb. pressure extensions. Seven 1200-lb. installations were indicated; none of the lower pressure were reported.

Pioneering started by the Boston Edison Co. and manufacturers of its initial Edgar Station equipment in 1925 has now developed thoroughly satisfactory installations that have paid and will pay dividends. Extra costs above those of low-pressure equipment have been paid for many times over by coal savings in actual, existing installations.

Now, the industry generally realizes that 1200-lb. "steam-table" gains can be realized in practice. Turbine efficiencies do not slump at the higher pressures. Boiler operation does not suffer losses due to frequent outages. Piping troubles do not develop and feedwater pumping troubles are not such that calculated economies are unattained.

Compared with 300-lb. steam pressure, 1200-lb. adds 5 per cent to fixed charges but reduces coal charges 15 per cent. A rule-of-thumb applying approximately to the average power plant indicates that fixed charges equal fuel costs. Thus a net reduction of 10 per cent in coal charges is effected after paying extra fixed charges.

Though high pressure can be accepted for most installations with assurance of its ultimate financial success, it cannot be expected to give immediate operating success, if low pressure technique, only, is applied.

Operating procedures successful for 300 lb. are positively unsatisfactory, in some departments, at 1200 lb.

WATER AND FUEL SUPPLY CONTROL

High pressures have dwarfed water storage in boiler drums. It is hardly accurate to speculate on "pump-through" and "flash" boilers as being a development of the future. From an operating standpoint, they are essentially present now. When all water in a boiler drum is emptied in 90 sec. after feed stoppage, that boiler is scarcely better than a "pump-through" unit. To sense an interruption of feedwater flow and get water delivery from a pump that requires 30 sec. to bring to speed, both before the 90 sec. elapses, is impossible. Feedwater supply reliability must be that of the "pump-through" boiler.

Furnace heat supply rate must be far more accurately proportioned to electrical demands than in the case of liberal-water-storage, low-pressure boilers. Calcu-

*Asst. Chief Engineer of Power Plants, Milwaukee Electric Railway and Light Co.

lations applied to a high-pressure installation recently indicated that a 30-sec. coal feed interruption would cause dropping load from full to 50 per cent. It is easy to realize the importance of readily controlled fuel burning apparatus, both from the standpoint of rapidly reducing heat supply to zero and from maintaining at 100 per cent every second. Even a relatively large pulverized-fuel furnace contains fuel for less than 5 sec.

Water Conditioning

Tube maintenance is not a matter of course in high-pressure boilers. Moreover scale formation is not the important trouble that might be expected. Corrosion is hardly the best descriptive term for the major hazard. It is not a rusting or pitting process; it is really an accelerated procedure of "eating" through the thick walls of high-pressure tubes in only a few weeks.

A rule-of-thumb from chemical practice allows one to account for the enormous difference in steam boiler corrosion at high and low pressures. To reflect that 1200-lb. pressure is four times 300-lb. pressure, or that 580 deg. F. boiler water of the former is only 40 per cent higher in temperature than 420 deg. F. boiler water of the latter, is of no help. But using the rule that most chemical reactions double with 20 deg. F. increase in temperature makes one apprehensive of the higher pressure dangers. Study of the following few figures shows this point best.

Rise of temperature is 160 deg. F. for 1200-lb. steam over 300-lb. steam. If chemical reaction rate doubles for each 20 deg. F. temperature rise, for 160 deg. rise it doubles eight times and becomes $2^8 = 256$ times as rapid.

The 256 times figure may possibly be grossly in error, but it does serve well to illustrate the relative importance of anti-corrosion control at high and low pressures. From experience with both pressures one is caused to feel that the figure is about right.

This feature of high-pressure corrosion is pleasing: Never has it been observed in the absence of feedwater oxygen. Close observation of a condition testing this simple but important point affords at least local basis for the statement.

How much oxygen can be tolerated in high-pressure feedwater? For positive success under all conditions, the answer is "zero." Methods of oxygen measurement not capable of indicating 0.03 c.c. per liter or less have been known to accompany severe corrosion troubles that kept high-pressure boilers out of operation almost as much as in service. It is realized that few stations can average better than the above figure under all varieties of power plant conditions but the need of zero oxygen is nevertheless reiterated.

Poor circulation within tubes exposed to moderate rates of heat transfer can cause serious corrosion. Common experience with bowing of intermediate tubes of a bank has generally proved absence of sufficient water and presence of much steam, with resultant overheating. This increase in temperature, in the presence of oxygen, heightens the corrosion rate figure above the 256 factor previously derived.

Oxygen control problems, of which there are many and varied, have been solved at one plant by reasonably good control accompanied with chemical deäeration by an iron compound. This finely divided precipitate removes the last 0.03 c.c. per liter that is so difficult to eliminate thermally and mechanically and neutralizes large quantities occasionally inevitable.

Best condenser vacuum performance automatically affords lowest oxygen. Theoretically, condensers are the best deäerators since oxygen is least soluble in water at low pressures. Direct pumping through closed heaters to the boiler affords a system that is least likely to cause occasional excessive oxygen.

Feedwater Pumping

High water temperature, caused by use of multiple-stage feedwater heating and lay out to pump the heated condensate are mostly responsible for current pumping troubles. Most mechanically satisfactory packings are slightly soluble at temperatures occurring in water glands which pack against water of over 300 deg. F. temperature and 300 lb. pressure, hence their life is unduly short.

Pumping through the high-pressure extraction heaters and handling 200-deg. F. condensate affords power savings as well as mechanical advantages. The specific volume of water increases so rapidly at present day feedwater temperatures that the above plan nets 8 per cent power saving with 350-deg. F. condensate and 15 per cent with 450-deg. F. water. Strict adherence to established tube standards is necessary when equipping extraction heaters for high-pressure pumping.

Incidental Advantages of High Pressure

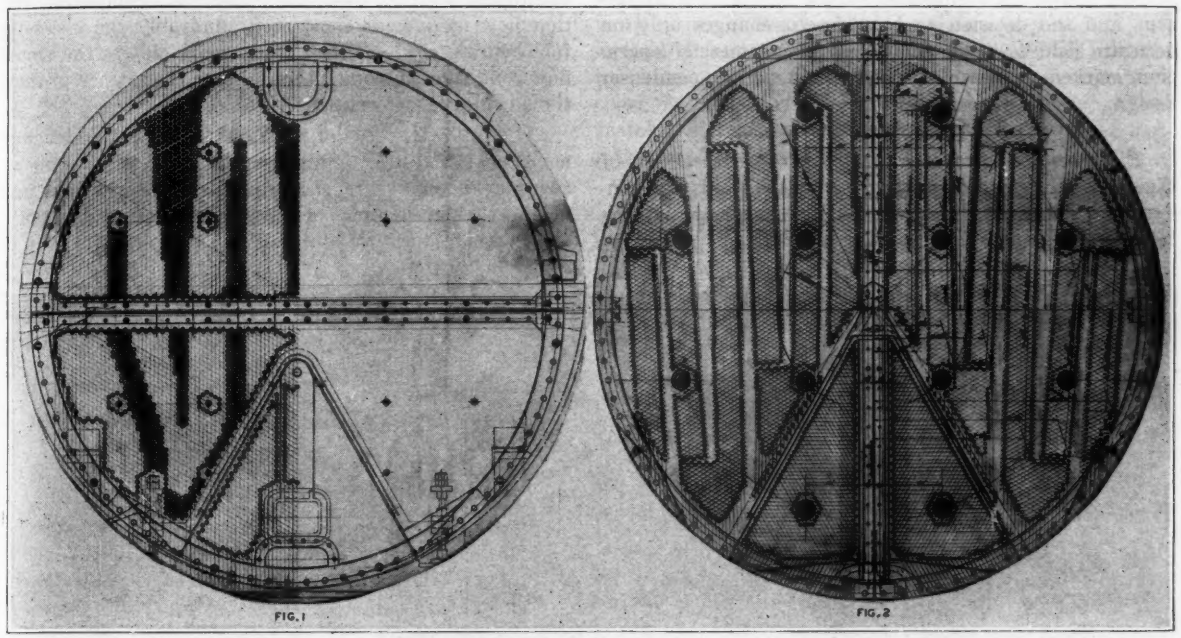
Excellent boiler water level stability proves the advantage of having to handle smaller steam volumes in the circulation system. There is no indication of insufficient circulation due to lack of head differences. It seems quite clear that the major problem in most boiler and furnace-tube circulating systems is one of disposing of large steam volumes without excessive resistances. High pressure greatly assists this major problem. There appears little to be gained by the pump-through type of boiler for high pressure.

High pressure so increases allowable mass flow rates in superheaters and high-pressure steam is so much more favorable in specific heat and conductivity than low-pressure steam that it is nearly as effective in cooling tubes as is water. Radiant superheaters are more easily designed for the higher pressure and experience proves their maintenance more favorable.

Reheating is not a handicap of high pressure. Like extraction heating, it is a means of increasing the economy difference between high and low pressures; both net greater gains at higher pressures. It appears that reheating of the future will be accomplished with ease in large single-boiler, single-turbine installations. Both initial and reheat steam temperatures will be high and uniform throughout a wide load range.

In conclusion, one may say that: 1. High pressure has "arrived." 2. High pressure pays. 3. Better operating technique is needed for higher pressures. 4. Incidental advantages of high pressures assist many major problems.

Internal combustion engines use either an electric spark, hot bulb or heat of compression to ignite the fuel.



TUBE SHEET ARRANGEMENT FOR RIVERSIDE NO. 8 AND AVON NOS. 1 AND 2 UNITS

CONDENSER DESIGN

Based on Accurate Tests

*By C. L. Waddell**

HISTORICALLY surface condenser design is divided into two periods, one in which theory was the basis of design and the other when definite knowledge of steam flow conditions became the basis for design and proportion.

During the first period each year saw numerous designs on the market and many changes taking place, all based on theory. Due to a lack of accurate testing equipment and to difficulties encountered in testing condensers in actual operation, these theories were never completely proved or disproved. Naturally, progress in condenser design was slow, for the designer, lacking a definite knowledge of steam flow conditions, was groping for improvement in seemingly logical changes.

In 1924, the Worthington Pump & Machinery Corporation brought out a new design based upon the theory that a shorter path of travel of steam and air through a condenser would reduce condenser pressure drop and give better vacuum at the turbine exhaust. To show the development of this theory, let us assume a thin bank of tubes laid out in horizontal position with steam coming down uniformly in a vertical direction and passing through the bank. It would seem logical that the pressure drop in a condenser of this kind would be low and the air liberated in condensation would have little effect upon the heat transfer of tubes in its path, due to its low quantity in a thin bank. Although the theory is logical, the design would not lend itself readily to commercial proportions of a condenser. It was, therefore, necessary to fold the thin tube layer upon itself and fit it into a condenser shell of commercial proportions as shown in Fig. 1. This tube layout was used first in a 34,000-sq. ft. condenser for the Louisville Gas & Electric Co. in 1924. Coincident with the development of the new design, the Worthington engineers developed special test equipment, as they had come to the conclusion that, until more was known by actual test about the flow of steam and air through a condenser, little real progress could be made in con-

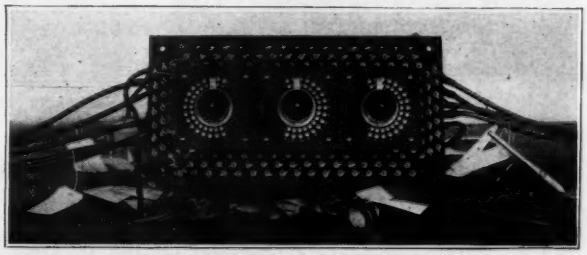


FIG. 3. SWITCHES, THERMOMETERS AND CABLES FOR TEMPERATURE MEASUREMENTS

*Condenser Engineer, Worthington Pump and Machinery Corporation.

denser design. Development of the special test apparatus and the decision to base design changes only on accurate field tests of condensers in commercial operation, marked the dawn of a new era in surface condenser design.

Tests of Condensers in Use

First tests to prove or disprove the correctness of theory of the new design were run on the Louisville condenser. The tube sheet was drilled as shown at the left in the headpiece, so that tube layout could be changed as test results might dictate. Tests were begun with 34,000 sq. ft. of installed surface. It was found that by a rearrangement of the tube layout in accordance with the test results, surface could be reduced to 28,435 sq. ft., yet obtain better performance than was obtained on a 34,000-sq. ft. condenser of the older design in the same station. Tests of pressure and temperature drops across the tube bank indicated that steam flow was in accordance with the design theory and that the drop decreased as the impeded path of steam and air was made shorter. The decreased pressure drop, coupled with the increased performance proved that the basic principle of the new design was sound. While the test equipment used on these tests was crude compared with that now used, it demonstrated admirably the necessity for accurate equipment to study more closely the steam flow conditions in condensers, so that the proper proportions could be determined.

The following year of 1925 was spent in the development of the testing equipment to the high degree of accuracy necessary in such delicate measurements and also in the development of a condenser design in accordance with test results at Louisville.

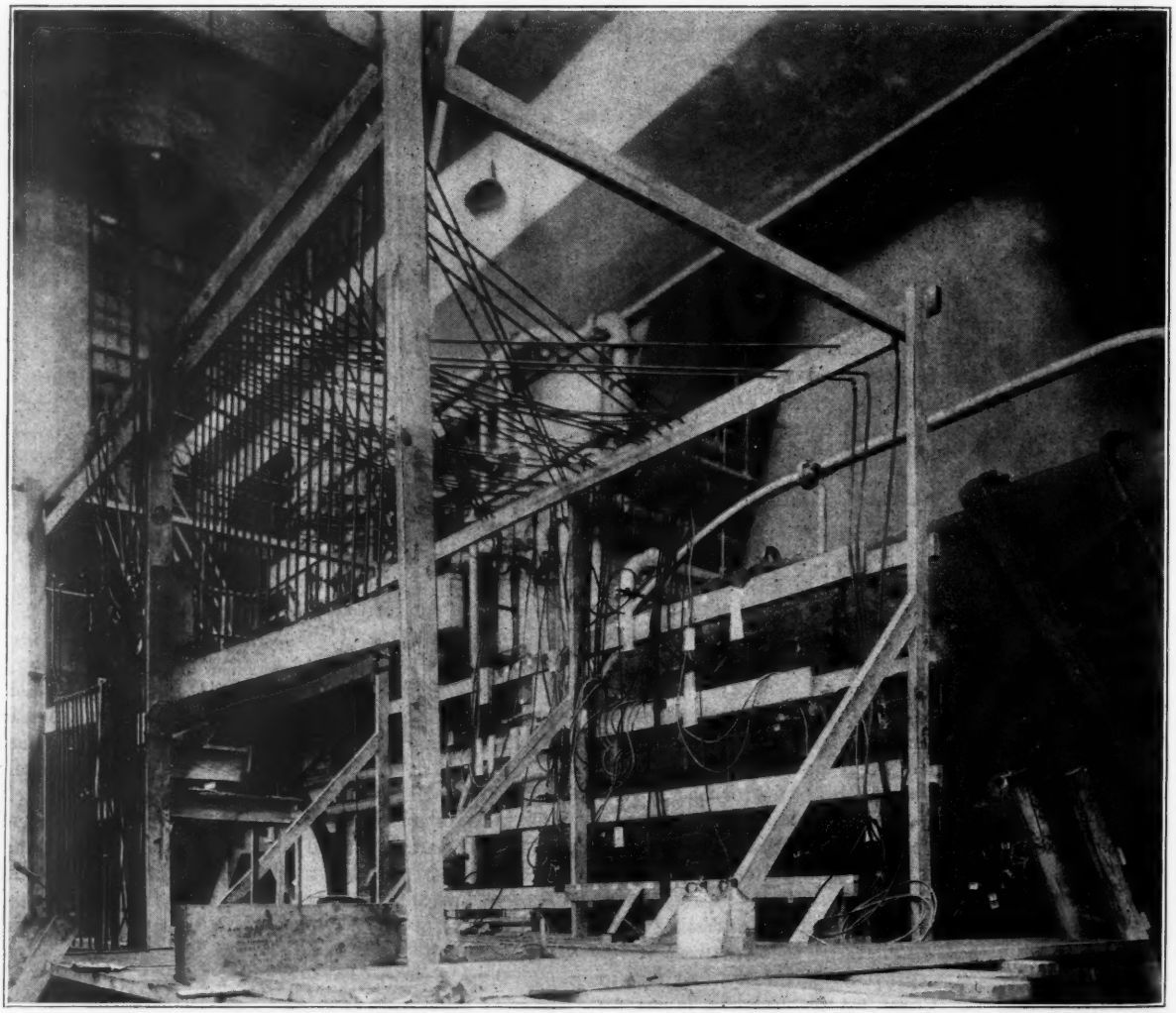


FIG. 4. TEST EQUIPMENT AS INSTALLED AT CONDENSER

In the summer of 1926, the Avon Station of the Cleveland Electric Illuminating Co. was placed in commercial operation. The original installation consisted of two 35,000-kw. turbines, each served by a 42,000-sq. ft. Worthington single-pass horizontal surface condenser of the folded tube bank design shown at the right in the headpiece. This was developed from the Louisville tests. It was realized that single-pass condensers presented less difficulty in testing than two-pass condensers, hence permission was requested and granted to test Unit No. 1 at the Avon Station.

Late in the fall of 1926 were begun what were probably the most extensive condenser tests ever conducted

FIG. 5. TYPICAL INSTALLATICN OF TEST INSTRUMENTS

on a large unit, covering a period of five months. Flow of steam and air through the condenser were studied by obtaining three independent sets of observations. One set was concerned with temperature changes throughout the steam space, as measured by resistance bulb thermometers. The theory on this set of observations was that steam flow would be from the region of higher to the region of lower steam space temperature. The resistance bulb thermometers, cables and switches used for temperature measurements are shown in Fig. 3. The method of bringing cables out through the water boxes by means of tubes which were open-ended in the steam space is shown in Fig. 4. The set up of the cables, switches and Wheatstone Bridge used in recording temperatures is shown in Fig. 5.

The second set of observations was concerned with pressure changes throughout the steam space as measured by manometers, which recorded pressure differentials between points where steam space temperatures were taken. The theory on this set of observations was that steam flow would be from the region of higher to the region of lower absolute pressure. The open-ended tubes which carried the thermometer cables out through the water box were piped to a manifold as shown in Fig. 5. Thus it was possible to get the pressure differential between any two points in the condenser by opening the proper valves to the manometer. Provision was made on the manifold for blowing out and draining to preclude the possibility of false readings of pressure differentials, caused by water clogged tubes or piping.

For the third set of observations, water temperatures were taken from tubes at 94 points on the tube sheet as observed on resistance bulb thermometers mounted on lances inserted in the water box through a ball and socket joint. The theory on this set of observations was that the temperature rise of the circulating water through any tube was a measure of the quantity of steam condensed by that tube; furthermore, that a decreasing water temperature rise on successive tubes in the path of steam from inlet to exit lane through the

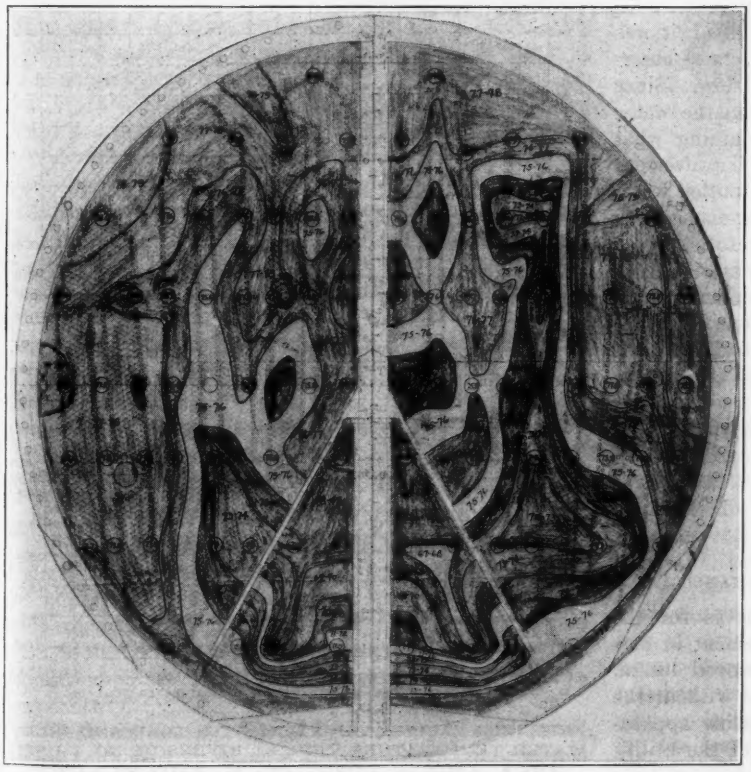


FIG. 6. ISOTHERMAL CHART OF OUTLET WATER TEMPERATURES, AVON NO. 1 UNIT

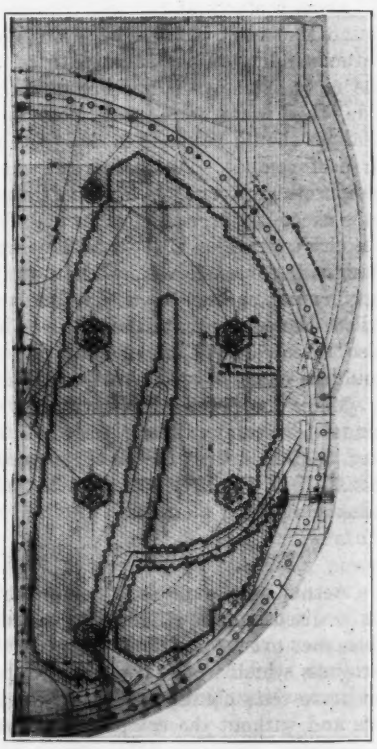


FIG. 7. TUBE SHEET AVON NO. 3 UNIT

DATA FROM CONDENSER TESTS AT RIVERSIDE AND AVON

Location	Riverside Louisville				Avon, Cleveland			Avon, Cleveland					
Unit	No. 8				No. 1			No. 3					
Condensing surface sq. ft.	28,435				42,000			42,000					
Condensing surface sq. ft. per kw.	1.14				1.2			1.2					
Length between tube sheets, ft.	18				22			22					
Number of tubes	6,030				8,360			8,360					
Outside diameter of tubes, in.	1				0.875			0.875					
Thickness of tubes, No. BWG	18				18			18					
Circulation, number of passes	2				1			1					
Dates of tests	Sept. 8, 1928				Aug. 21, 1928			Sept. 11, 12, 13, 14, 1928					
Test No.	1	2	3	4	1	2	3	1	2	3	4	5	6
Wt. steam condensed per hr... 1000 lb.	295	232	172.5	120	146.0	224.3	320.6	150.4	193.5	230.2	274.5	320.2	355.1
Steam condensed per sq. ft. per hr., lb.	10.37	8.15	6.06	4.22	3.48	5.35	7.63	3.56	4.60	5.48	6.53	7.62	8.45
Heat loss per lb. steam condensed B.t.u.	950	950	950	950	945	925	916	940	932	924	917	916	921
Abs. condenser inlet pressure in kg.	2.036	1.809	1.606	1.526	1.375	1.647	2.011	1.085	1.226	1.298	1.373	1.520	1.584
Saturation temp. at inlet press. deg F.	101.76	97.83	93.95	92.29	89.00	94.83	101.45	81.62	85.44	87.21	89.00	92.25	93.57
Temp., inlet water, deg F.	76.	76.5	76.5	76.5	75.0	75.0	75.2	71.69	72.76	72.36	71.86	72.12	71.38
Temp., outlet water, deg F.	89	87	84.5	82	80.8	83.7	87.3	76.96	79.65	80.73	81.62	83.84	84.28
Temp., rise of water, deg. F.	13.	10.5	8	5.5	5.8	8.7	12.1	5.27	6.89	8.37	9.76	11.72	12.90
Heat head, deg. F.	25.76	21.33	17.45	15.79	14.00	19.83	26.23	9.93	12.68	14.85	17.14	20.13	22.19
Terminal temp. difference, deg. F.	12.76	10.83	9.45	10.29	8.20	11.13	14.13	4.66	5.79	6.48	7.38	8.41	9.29
Log. mean temp. difference, deg. F.	18.5	15.5	13.0	12.85	10.85	15.06	19.57	7.00	8.75	10.05	11.55	13.35	14.85
Coefficient of heat transfer, B.t.u.	533	500	443	512	303	327	357	481	491	504	519	523	524
Water circulated, 1000 g.p.m.	43.2	42	41	41.5	47.6	47.6	49.5	53.6	52.3	50.8	51.5	50.0	50.7
Water velocity, ft. per sec.	7.2	7.0	6.83	6.92	3.87	3.87	3.95	4.32	4.22	4.10	4.15	4.02	4.07

bank would indicate that the efficiency of the tubes as condensers was decreased, due to the accumulation of air liberated on previous tubes during condensation and also due to the decreased velocity of the air vapor mixture through condensation and friction. It was assumed on this set of observations that water velocity through each tube was the same and, while we have proof that this assumption is not entirely correct, it held reasonably well over the 94 points and was used as a basis of this study of steam flow.

Holes in the center of each manhole plate through which the lances were inserted are shown in Fig. 4.

Since no pictures are available of the Cleveland test equipment, set up of the test equipment shown in Figs. 4 and 5 is shown as typical.

Design Changes Based on Tests

From a study of the test data thus obtained, it was found that each of the three independent sets of observations indicated the same path of steam flow. Since the most extensive study had been made on the water side, these data were used most in determining what changes should be made in design to effect improvement in performance. An isothermal chart of outlet water temperatures for each load condition was made on a tube sheet layout, as shown in Fig. 6. Careful study of the charts revealed that steam flow was not as originally designed, for each vertical half of the condenser was performing as one large tube bank with one exit lane where the center exit lane of three banks had been. It also revealed that internal air cooler and shell design could be changed with beneficial results.

Many improvements in design were made, based on actual test data. These resulted in the design shown in Fig. 7 of half the tube sheet, for unit No. 3 which was installed at the Avon Station in the fall of 1928, the other half being identical.

Test Data Show Improved Performance

Actual test data and performance curves for the units discussed show definitely the improvement in performance over a period of 4 yr. due to improved design, progress which would have been impossible without the accurate tests obtained with the special testing apparatus and without the complete coöperation of the utility companies.

Test data on unit No. 8 at Louisville and units Nos. 1 and 3 at Avon are given in the table. Heat transfer coefficients in these tables are for conditions existing at the time of the test. Considerably higher coefficients are obtained when steam loading and circulating water velocity are increased. Coefficients in excess of 710 B.t.u. have been obtained on unit No. 3 at Avon. From this test data and a knowledge of the behavior of a condenser under various conditions of loading and water temperature we are able to plot the approximate performance curves from the test data. Figure 8 shows performance curves for unit No. 8 at Louisville, Fig. 9 for unit No. 1 at Avon, and Fig. 10 for unit No. 3 at Avon. Since Nos. 1 and 3 at Avon have the same surface and operate under identical conditions, com-

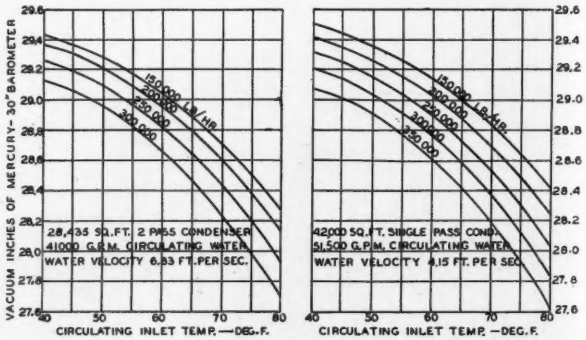


FIG. 8

FIG. 9

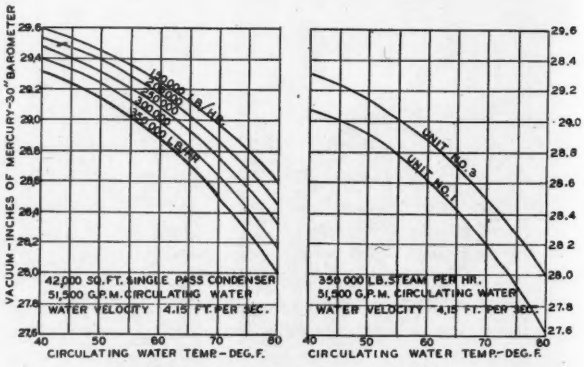


FIG. 10

UNIT NO. 3
UNIT NO. 1
350,000 LB. STEAM PER HR.
51,500 G.P.M. CIRCULATING WATER
WATER VELOCITY 4.15 FT. PER SEC.
CIRCULATING WATER TEMP.-DEG.F.

FIG. 11

FIGS. 8-10. VACUUM VARIATION WITH LOAD AND INLET WATER TEMPERATURE. FIG. 8. RIVERSIDE NO. 8 UNIT. FIG. 9. AVON NO. 1 UNIT. FIG. 10. AVON NO. 3 UNIT FIG. 11 COMPARISON OF PERFORMANCE AVON UNITS NOS. 1 AND 3

parative performance curves in Fig. 11 at the same load and water quantity show the improvement of unit No. 3 over unit No. 1.

Improvement in condenser performance shown in the test data and curves can be attributed to design changes based on a definite knowledge of steam and air flow through a condenser. Accurate tests have been established as the only justification for design changes and testing equipment which has made possible such gain in performance is still being improved. Continued study of condensing units in actual operation and the continued coöperation of the utility companies will enable the condenser manufacturer to improve his product progressively to their mutual benefit.

Superheater Development

BEGINNINGS OF SUPERHEAT; CONSIDERATIONS IN DESIGN AND OPERATION WITH HIGH STEAM TEMPERATURES. BY CHARLES W. GORDON*

ENGINEERS are so busy looking forward that we have no time to look backward, yet many developments which we consider to be strikingly new were used hundreds of years ago. Steam has been generated for untold centuries, the first mechanical device using steam to produce motion being the familiar reaction turbine made by Hero of Alexandria in 150 B.C.

From that time until 1663 development in the art of using steam paused. Then the Marquis of Worcester described the steam pump and in 1681 Dr. Denys Papin improved upon this pump by providing for the injection of hot metal into the floating diaphragm which separated the steam and water, this metal serving to superheat the steam, the first recorded use of superheated steam. Next James Watt advocated the use of a low degree of superheat and a pressure of not over 7 lb. per sq. in.

1200 DEG. IN 1825

Following Watt came the reign of the Perkins family from 1824 to 1894, started by the celebrated Jacob. This family was so far in advance of even our times that it was subjected to endless persecution and ridicule. Do you realize that in 1825 more steam generators were built for pressures of 1600 to 2000 lb. per sq. in. than were built in 1925, a century later? Perkins was the first recorded advocate of extremely high pressures. During his experiments, he generated steam at 1200 deg. F., thus being the first to generate high steam temperatures. It is certain that these astounding developments in an era still strongly influenced by the low-pressure and temperature teachings of Watt resulted in untold grief to this remarkable family, which, no doubt, explains the following plea for tolerance found in the family history:

"Why not let the facts stand for themselves and received due consideration, even though they conflict with old and apparently well established theories?"

HIGH TEMPERATURE WAITED ON LUBRICATION

In general, during this period "high pressures" ranged from 30 to 150 lb. per sq. in. The development of superheaters was retarded by poor lubricating oil. Superheaters in many cases were simply steam dryers and 50 deg. F. was about the maximum developed. This condition obtained well into the early years of the present century.

With the development of better lubricating oils and more suitable and reliable metals, steam temperatures have gradually increased. In the United States high temperatures were first used extensively in steam locomotives, central station development following rapidly up to operating with the temperature 750 deg. F. Our

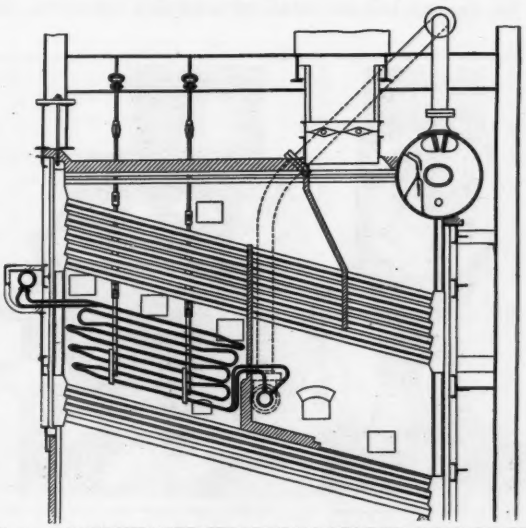


FIG. 1. SUPERHEATER HEADERS LOCATED OUTSIDE THE HIGH TEMPERATURE ZONES

European contemporaries have progressed faster than we and can report one station (Langerbrugge) in commercial operation since 1924 at 750 lb. per sq. in. and a final temperature of 850 deg. F. Many recent continental examples are listed with operating temperatures ranging from 787 to 932 deg. F., the average being about 850 deg. F.

For years, in the United States, 750 deg. F. was considered the limit. At the present time the tendency is to follow the lead of our European friends and we have a few stations under construction to use a final temperature of 825 deg. F. An exception is the notable development of the Detroit Edison Co. in which steam at 400 lb. pressure and 1000 deg. F. final temperature will be used. In their present frame of mind, power plant designers are no longer content to accept the rejection of their studies by boiler, superheater and turbine manufacturers as involving visionary and impracticable schemes, an attitude which has resulted in a striking advance in the design of all power plant equipment during the last ten years.

Problems of the superheater designer have multiplied, likewise the importance of the superheater in

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relation to the steam generating unit. The space required and the design of the superheater often determine the design and character of the boiler. For 100 to 200 deg. F. superheat, the space required is of little consequence in steam generator study. Increase the superheat to 400 or 500 deg. F. and an entirely different situation exists, as the superheating surface has increased from 5 per cent of boiler heating surface to 35 and 40 per cent.

Increasing steam temperatures have accelerated the study of metal properties, so that designers are now able to get low-temperature equipment with a far greater true factor of safety than heretofore and high-temperature equipment which will give service for a definitely pre-determined number of years.

Creep Effect

New developments are always accompanied by new terminology. The most significant of these is "creep." If we are to believe some present-day prophets, the

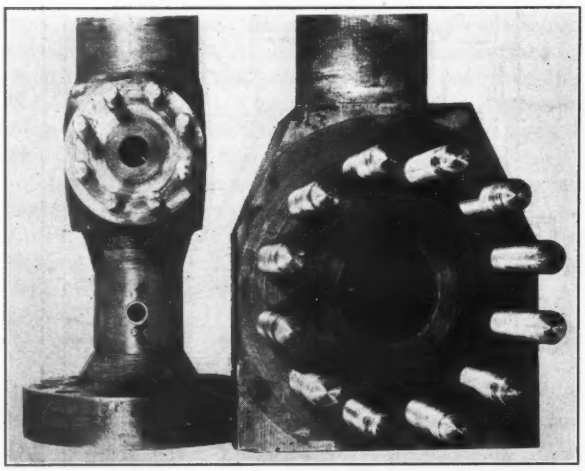

FIG. 2. INTEGRAL ELBOW AND FLANGE CONSTRUCTION

dreams of the power plant operator should be disturbed by the fear that his heretofore stable equipment is increasing in size at an alarming rate. He is told that his boiler and superheater tubes, as well as his pipe lines, are constantly increasing in diameter. Metallurgical research has definitely proved this to be true, but, at the same time, that this growth has been in existence under the operating conditions regarded as stable in years gone by. Rational thought has, therefore, concluded that creep, when isolated and properly accounted for, need add little to the concern of the operating staff.

To account properly for the effects of creep, an exact knowledge of metal temperature during three periods of operation must be taken into account. These three operating periods are: 1. Starting up period; 2. Normal operating period; 3. Emergency period.

Assume a superheater designed for 850 deg. F. final steam temperature. Good plant operation demands that steam be circulated through the superheater soon after the fire is lighted, which is ordinarily accomplished by opening the drain valve on the superheated steam header and allowing steam to blow to atmosphere until the stop check valve lifts. Under such conditions of operation the maximum metal temperature will be approximately 1000 deg. F. Unless the drain valve is open the metal temperature will approximate the surrounding gas temperature, which may be from 1400 to 1800 deg. F.

During the second or normal operating period, the metal temperature of a high-velocity superheater will be from 900 to 950 deg. F. For a low-velocity superheater it will be 1000 deg. F. or more. Thus high steam velocities, while of importance for low steam temperatures, are vital for high steam temperatures.

Consideration must be given to the third or emergency period, although its effect can seldom be properly forecast. This period constitutes a sudden and an abnormal stoppage of steam flow, caused by the tripping of the prime mover or other unusual emergencies. Under conditions of good operation, this period will be of short duration but may result in a sudden increase in metal temperature to 1200 to 1400 deg.

In evaluating these three periods, greatest weight should be given to the second, the normal operating period, choosing a metal stress which will result in creep at a rate predetermined as satisfactory and a material which will not oxidize in any of the three periods.

Materials for Superheaters

It is natural that ordinary low carbon steel tubing should have been tried first for the increased steam temperatures. In the Langerbrugge station, such steel operates satisfactorily at 750 lb. per sq. in. and 850 deg. F., so there is little doubt that we can use such steel for steam temperatures up to 850 deg. F., with the possible exception of unprotected radiant superheaters. Where radiant superheaters can be partly screened by water wall tubes to take the wash and impingement of the flames, carbon steels may be used for this temperature.

Use of carbon steels at higher temperatures has been extended by surface treating, the process most used at present being known as calorizing. This coats the steel with an aluminum-iron alloy which is resistant to oxidation up to 1650 deg. F., which is equal to the oxidation resistance of our present day alloys and has made creep the limit to the use of low carbon steel. Thus surface-treated low carbon steel may be used for steam temperatures up to 1000 deg. F., with moderate pressure.

For the combination of high pressures and high temperatures, alloy steels are indicated. With the discovery of a low-content alloy steel, which can be produced cheaply and then calorized, it is probable that the entire range can be so covered. Whether this or the use of high-content alloy steels is the economic answer is in the hands of the metallurgists.

Of the alloy steels the 18—8 (18 per cent chromium, 8 per cent nickel) series has decidedly the best creep properties but these steels in tubular form unfortunately cost approximately $1 per pound. True, only the high temperature portion of the superheater need be made of this material but, even with that limitation, the additional cost is a distinct drawback to its extensive use. As a result, research metallurgists have concentrated on the production of a lower content alloy having less desirable properties but which can be produced for a fraction of the cost.

It has been seen that high temperatures have refined superheater design. This is likewise true of the con-

ductors from the superheater outlet to the turbine throttle. Alloys have been extensively used in valve design. Flanged connections and flange bolts are still a problem and undoubtedly power plant designers will turn to welded pipe lines for the solution. Fortunately, tubes and conductors creep in diameter only, not in length. Thus nature has relieved the operator of that worry.

Details of Design

Hairpin loop construction places definite limitations on the location of the headers. Headers of a moderately high temperature superheater located within the boiler setting are a possible source of trouble and have often been located in most inaccessible positions. For high temperature service, location within the setting is out of the question. Thus outside header locations are the rule, as shown in Fig. 1 for an interdeck superheater of the multiple-loop, single-pass type.

In the interests of the elimination of flanged joints, it is now possible to obtain tees and elbows forged integrally with the headers and connecting pipes, Fig. 2, which greatly simplifies construction and reduces the hazard of high-temperature design.

Due to the necessity of installing surface in high temperature gas zones, the problem of supporting the superheater is intensified. Alloy steels have been extensively employed and have given remarkably good service.

With the use of multiple-loop unit construction, the old bogey non-drainability has been laid to rest. This is not surprising, when it is realized that more than 57,000 American-built locomotives equipped with non-drainable superheaters are performing their duty day in and day out under operating conditions which would not be tolerated in a modern stationary plant.

Superheat Regulation

The superheater characteristic, or the steam temperature plotted against load has always been of concern to power plant designers, especially for high superheats. Thus, for 100 deg. F. superheat, a 10 per cent variation is only 10 deg. F., while for 500 deg. F. superheat, the same percentage variation becomes 50 deg. F., a figure of consequence.

Our European contemporaries have used the superheat regulator as standard practice, normally in the form of a desuperheater or damper arrangement. An excess quantity of superheating surface is installed in a convection zone. When the steam temperature reaches an excessive value, part of the surface is bypassed or the steam is partially desuperheated so that a reasonably constant steam temperature results.

Up to the present time, American practice has countenanced no extensive use of regulating devices. Constant temperatures have been obtained by locating the superheating surface closer and closer to the furnace and finally in the furnace walls. With interdeck and intertube superheaters, remarkably flat characteristic curves have resulted, due to the fact that both types, especially the intertube are fundamentally a combination of radiant and convection superheater. Flat characteristic curves have also been obtained by connecting radiant and convection superheaters in series. A comparison of characteristic curves for straight convection, intertube and interdeck superheaters is shown in Fig. 3.

Ever working to improve his creation, the power plant designer is now demanding flatter and flatter characteristic curves for high temperature superheaters. To fill this need it appears that we must borrow from our European friends. The desuperheater is one solution to the problem, its proper use requiring a superheater with excess surface, hence a costly equipment. It is also probable that in some designs gas recirculation can be used, with a hot gas fan similar to that in successful use for oil still service. Recirculation has been thoroughly established in refinery work and there is reason to believe that it can be applied in power plants.

With present equipment, the characteristic curve can be flattened in many cases by some investigation on the part of the efficiency department of the plant. All changes which affect steam temperatures must originate in the furnace; it is, therefore, reasonable to start at that point to change the shape of the curve. Assume that, over the range of loads normally encountered, a

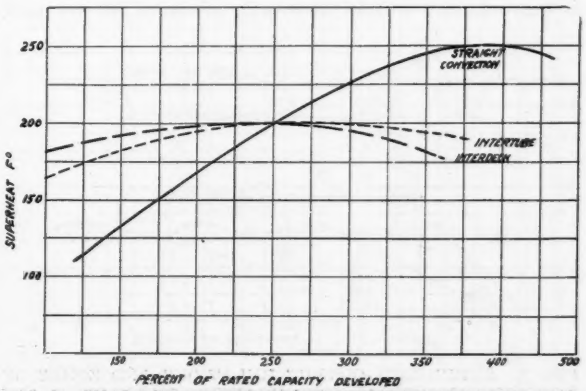

FIG. 3. CHARACTERISTIC REGULATION CURVES FOR CONVECTION, INTERDECK AND INTERTUBE SUPERHEATERS

given curve is obtained with CO_2 held constant. At low loads, the steam temperature may be raised by lowering the CO_2 or changing the gas distribution across the furnace width, the latter being accomplished by burning more fuel at the sides than in the center. When burners and side water walls are used, it is well to study the flame impingement. Flame impingement results in a great increase in heat transfer in the water walls, hence a lowering of gas and steam temperatures. Study on the subject of this paragraph will normally result in a distinct flattening of the superheater curve.

It is hoped that the interest of readers will be so aroused by this article that they will demand better and still better power plant equipment. In meeting such demands, the manufacturer is stimulated and the user has available equipment of the highest order.

Generating station net output of electrical energy of The New York Edison System of companies in 1930 was 6.5 per cent greater than the output for 1929, Matthew S. Sloan, president, announced. The 1930 output amounted to 4,983,507,819 kw-hr. of electrical energy, which was 304,795,921 kw-hr. greater than in 1929. Also the highest demand for electrical energy on the System in 1930—called instantaneous peak load—was 1.8 per cent greater than the peak in 1929. The 1930 peak, which came at 5 p. m., December 23, was 1,247,800 kw.

Load and Plant Factors

Their Influence on Economy in Operation of Hydroelectric Stations. By S. Logan Kerr*

INCREASE IN the size of interconnected power systems has changed the aspect of operation for both hydroelectric and steam stations. On systems where both types of generating stations are available, it becomes possible to utilize each plant in a manner best adapted to its particular characteristics so as to secure the greatest economy in operation, hence the greatest financial returns. It has been found that steam plants usually give much better economy when operated on steady loads continuously, making them ideal for operation at high load factors. Studies of cost and operating economy show that, for average conditions, a steam plant is best adapted to load factors in excess of 50 per cent.

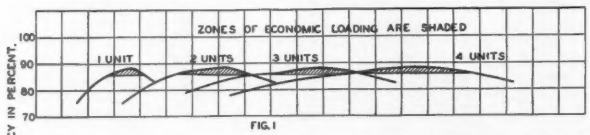

FIG. 1

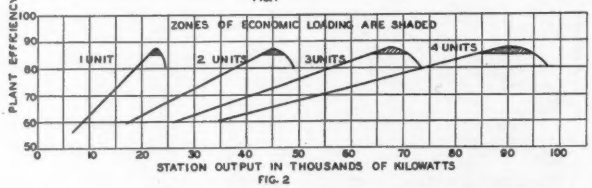

FIG. 2

FIG. 1. EFFICIENCY-OUTPUT RELATIONS AND ZONES OF ECONOMIC LOADING FOR FRANCIS TURBINE PLANT UNDER MEDIUM HEAD

FIG. 2. LIKE RELATIONS FOR PROPELLER-TYPE TURBINE PLANT

The cost of power still further decreases as the load factor approaches 100 per cent.

Hydroelectric Plants for Peak Load

Hydroelectric plants are particularly adapted to peak load operation, due to the almost immediate availability of the units for service. Once the dam and head works have been installed, additional capacity and additional pondage can usually be added at a nominal cost and the station converted from a high load factor plant to a low load factor plant. Some hydroelectric plants have been installed on an assumed load factor as low as 10 or 15 per cent. Still other plants are being installed with pumped storage, utilizing off-peak power for pumping and drawing this stored water through turbines to supply peak load assistance on the interconnected systems.

Proper coördination of steam and hydroelectric generating stations is a question which must be studied in each individual case as no rules can be laid down other than the most general, which would govern the operation of such combined system. This brief discussion will be devoted to hydroelectric plants and the various factors of operation with respect to maximum utilization and maximum economy.

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Most important of factors in hydroelectric plant operation are: Economic load distribution; operation at the economic output of the station; maintenance of the economic combination of units in service and maintenance of the maximum operating head.

Economic Loading of Water Turbines

Economic load distribution between units has been dealt with in several technical articles in the last few years. The basic principle, however, requires the various units to be operated at points where the slope of their power discharge curve is the same. Turbines of similar characteristics should be operated with equal distribution of load between units. For units of dissimilar characteristics, the schedule of load distribution for maximum economy may become quite involved due to the necessity of operating the units in accordance with the variation in slope of the power discharge curves.

With any given station, it is possible by automatic means to maintain the ideal schedule of unit loading without imposing additional burden on the operating staff.

To maintain the economic output of the station corresponding to the points of maximum efficiency for the various combinations of units requires a detailed knowledge of the unit characteristics. From test data it is possible to prepare curves or charts which will indicate very clearly to the operating personnel the points or zones of economic operation for any given station. Figure 1 shows such a curve for a medium head plant, in which a range of output equal to over 10 per cent of the unit capacities is permissible without suffering too great a loss in efficiency. Figure 2 shows a similar curve for a low-head, high-speed, propeller-type installation where the range of operation is restricted due to the inherent characteristics of this type of turbines. By the use of adjustable vane turbines, this plant could be made to show flat operating efficiency over a wide range but the adjustable vane type of turbine would be avoided, if the station is to operate only on fixed loads and be interconnected with large systems.

Operation of low or medium-head stations at their maximum economy point can be accomplished by manual means or the load limits on the respective governors can be blocked at a given point. In the former case, a certain fluctuation up and down will be experienced due to system speed changes requiring readjustments of the loading. In the latter case, the margin of power in excess of the point of maximum efficiency is unavailable for emergency service due to the effect of the load limit. A simple solution to this problem is the application of automatic load control, which holds the units at the desired loading points but permits the governors to function with respect to speed changes. As soon as the load changes from the desired value, it is automatically

returned to this point at any desired rate. This leaves the governors free to respond to sudden load changes and share in the system regulation, maintaining an average load within the range of good efficiency.

How Many Units to Run

To maintain the economic number of units or combination of units in service and to secure maximum plant efficiency is only another phase of maintaining the economic output of the station. Proper number of units to have in service depends upon the required reserve for the system and the necessary functions of starting and stopping units, synchronizing units and redistributing load between them. This also is susceptible of solution by automatic means, particularly in hydroelectric plants where the turbines are adapted to operation as synchronous condensers. New plants are usually designed for such service and units already installed can often by used as condensers by proper venting of the draft tube and runner. Several plants are now in operation in which the units are transferred automatically from condenser to load or from load to condenser in accordance with the variation in demand on the station, either when operating on base load or when controlling speed. All of this is accomplished, requiring no attention on the part of the operating staff.

Maintenance of Head

Maintenance of the maximum operating head is a factor of great importance in connection with medium and low head plants. In certain plants having a reasonable amount of pondage, peak loads are carried by increasing the draft from the reservoir causing a certain amount of draw-down in the level in the pond, together with an increase in the level in the tailrace for some conditions. Careful study is necessary to limit the draw-down of these ponds to a minimum, as the loss in power due to the decrease in head may cause a greater overall reduction in efficiency than is justified by the amount of peak load power available.

In certain plants operating on the run-of-river flow, it may be found that the operation of several units at their best efficiency point calls for too great a draft on the reservoir yet, if one less unit is utilized, their total discharge is less than the normal flow of the river. By proper means of operation, it is possible to shut down one unit for certain periods of time, allowing the head to build up and limiting the draw-down to much smaller amounts than would be the case were the output of the station less carefully adjusted in accordance with the requirements of the river flow.

Seasonal Variation and Load Regulation

Seasonal variations in flow and in the utilization of plants change their characteristics materially. In high-water season a hydroelectric plant should operate for maximum output on base load while in low-flow season it can handle variable loads and render peak load assistance for short periods of time. All these conditions are closely tied in with the method of load dispatching on a given system. With a knowledge of the plant characteristics available, competent load dispatchers can secure the maximum economic utilization of the various generating stations.

Figure 3 illustrates a typical daily load curve on an average generating system supplying a fair proportion of metropolitan load. The morning and afternoon peaks are illustrated together with the noon drop. This load has been divided into three sections, the first of which is shown as a base load which could be carried continuously over a 24-hr. period, requiring no adjustment. The second class may be designated as dispatched load which takes care of a variable amount of base load required in addition to the first block, to cover approximately the variations in hourly requirements. A third class of load can be designated as the regulated load, representing the margin between total demand and the sum of the base load and the dispatched load. This covers small variations in demand, also provides the necessary capacity to regulate the speed. This regulated load may represent anywhere from 5 to 20 per cent of the system generating capacity, depending upon the type and character of load supplied; the average value will be about 10 per cent for ordinary systems.

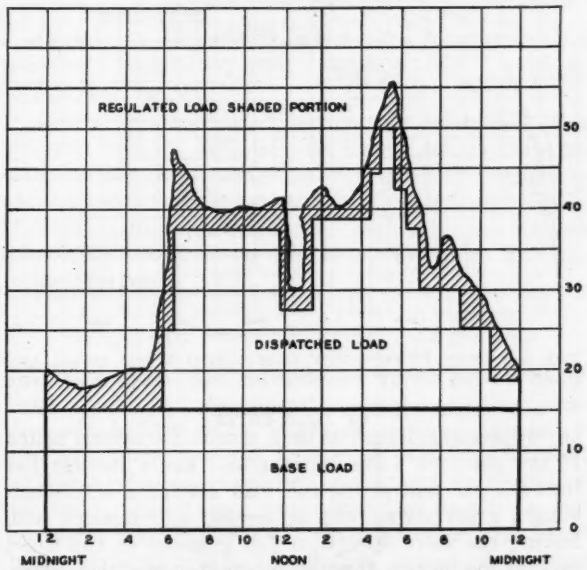


FIG. 3. TYPICAL DAILY LOAD CURVE WITH CLASSIFICATION OF LOAD AND FUNCTIONS OF DIFFERENT CLASSES

The regulated load can be adjusted either manually or automatically, decided preference being found for the automatic control as a function of system frequency.

Regulated load should include a margin of reserve capacity, immediately available from units already in operation. Stations supplying dispatched load can maintain a secondary reserve consisting of units not immediately available but which can be placed in service on relatively short notice, varying from several minutes in the case of a hydro plant to as much as several hours in the case of certain steam plants.

System reserve capacity should be the subject of much study with a view to determining which stations should be designated as primary reserve and which should be considered as secondary or delayed reserve. Primary reserve plants should have units capable of operating as synchronous condensers with the draft tube vented and the runner operating in air. Such units can be available almost instantly for service. A maximum delay of 20 or 30 sec. may be experienced, if penstock valves must be opened, or the turbines primed.

In plants capable of supplying secondary reserve, no units need be required to operate as synchronous condensers. Stations ill adapted for this type of service can act as primary reserve only if the units are partly loaded.

Shut-Down Units

Where units are shut down for an appreciable length of time, consideration must be given to the leakage through the turbines and valves, as this represents a dead loss which can be converted into kilowatt-hours if the leakage can be eliminated, the water stored in the reservoir and utilized for generating purposes.

In medium and high-head plants, it is considered good practice to supply penstock valves at or near the turbine casing intake. Where such valves are available they should be closed if the unit is to be out of service

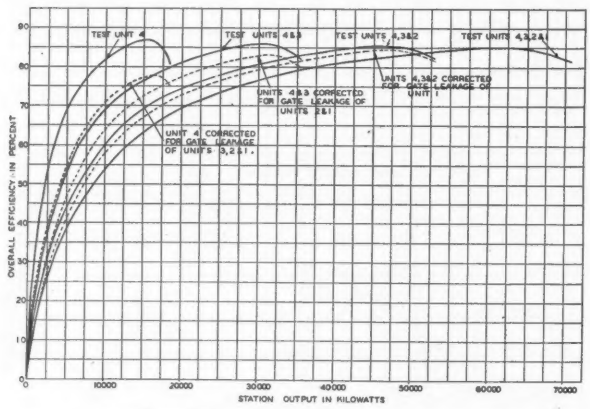


FIG. 4. TEST EFFICIENCY COMPARED WITH OVER-ALL PLANT EFFICIENCY CORRECTED FOR GATE LEAKAGE OF IDLE UNITS

any appreciable length of time, that is, for several hours. If the penstock valve is tight and has a leakage less than 0.1 per cent of the full load discharge of the turbine, a great saving will be secured as compared with leaving the valve open with full pressure on the wheel case, as the leakage through the guide vanes themselves, will seldom be less than 0.5 per cent of the full load discharge and may readily be as high as 5 or 6 per cent.

On low-head plants, the guide vane leakage can usually be maintained below 1 per cent of the full load discharge of the unit, if reasonable care has been exercised in the construction of the guide vane mechanism. After a period of 5 or 10 yr. of operation, this leakage will probably increase and, when it exceeds several per cent of the full load discharge of the unit, step should be taken to effect the necessary repairs. The losses due to leakage are just as important on the low-head plants as they are on the high-head stations, with the added difficulty that penstock valves are rarely employed in such plants and head gates are usually of the slow-acting type, requiring a considerable period of time to open or close them. The volume of water between the head gates and the turbine would be lost in any case and this volume may be equal to the amount of leakage which would be incurred, if the head gates were not closed. The proper maintenance of this part of the hydraulic turbine equipment is just as important as the proper care of the runners and runner seal rings.

Figure 4 shows efficiency curves for a station having four units under a medium head. A comparison is given of the test efficiencies with the actual operating efficiency of the station with one, two, three and four units in service, the difference being due to the correction for leakage through the units when shut down. This loss reaches large proportions, particularly in the case where only one or two units are on load, as would be the case during the off-peak hours.

If information on plant characteristics, economic loads and economic load distribution, together with the permissible draw-down of the ponds and characteristics of the individual plants is available to the load dispatchers and if they, in turn, utilize this information to its fullest extent, great savings in system operation can be secured. The maximum utilization of plant characteristics with respect to variations in load factors and also with the peculiar local conditions existing at the particular plant under consideration will usually secure financial returns ample to compensate for the time and effort devoted to the study of plant characteristics. The benefits to be gained from the use of automatic control devices for the simplification of load dispatching and of operation have been proved in the satisfactory performance of a number of installations of the Automatic Operator to control load distribution, plant output, system speed and maintain proper combination of units in service, as well as to insure the availability of primary reserve power. Still further developments in the field of automatic control will offer new and better means for the utilization of generating equipment.

To satisfy the continuing demand created by the Correspondence Course in General Illumination, in which more than 6000 students were registered in 1930, a revised edition of the course will be made available, it is announced, for which registrations may now be made with the Westinghouse Lighting Institute, Grand Central Palace, New York City.

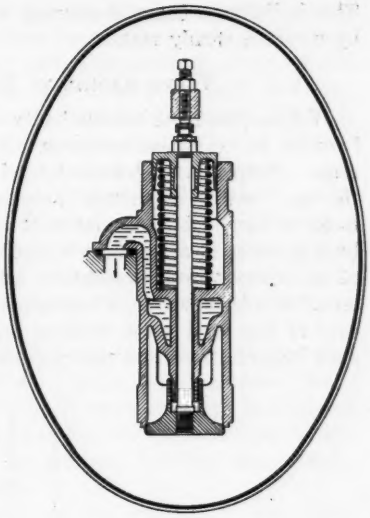
Technical data covered in the course was given in nine different lessons: Light Sources, Units of Light Measurement and Photometry, Principles of Light Control and Equipment, Interior Lighting Calculations, Commercial Lighting, Display Lighting, Industrial Lighting, Floodlighting, Street Lighting.

The revised course will contain additional assignments on Light Sources, Electrical Advertising and Conventional Home Lighting, but each question and problem in the assignments, which students are required to answer, will be changed completely.

This new course will be available throughout all of 1931 and is intended primarily for Central Station personnel that may be assigned to lighting work. No time limit for completion has been set or period specified when registrations should be made. The course will be a fixed Institute service for public utility light and power companies, electrical contractors and dealers, when and as they may find need of it for the education of their employees.

For convenience in installation and upkeep, shafting hangers should be so designed that the shaft can be removed without disturbing hanger position. Also convenient means should be provided for vertical and horizontal adjustment of boxes by means of screws, liners or wedges.

DIESEL ENGINE UPKEEP



PART IX. METHODS OF RECONDITIONING DIESEL ENGINE VALVES. OVERCOMING VALVE STICKING. MACHINERY AND GRINDING PROCEDURE AND DEVICES. GRINDING MATERIALS. TESTS FOR TIGHTNESS. CARE OF ENGINE-VALVE SPRINGS

IMPROPER LUBRICATION which may result in gumming up the valve stem with carbon, is one of the chief causes for sticky valves. When an exhaust valve action is affected in this manner by sticking, it closes in a peculiar way, at first almost seating, then hesitating, finally snapping shut due to the added impulse given by the compression pressure. Valves may be stuck so badly that they will remain open. This condition is revealed by misfiring of the engine. Misfiring, however, may occur also if the valve is sluggish in its action but in the latter case the slapping of the cam and its roller will be heard.

GIVE PROMPT ATTENTION TO STICKY VALVES

Sticky valves call for prompt action. If the engine cannot be stopped at once, the fuel to the affected cylinder should be shut off. A valve which seats after sluggish action most likely will leak. Valve action may be analyzed easily by taking a light spring card, stopping the indicator at about 60 lb. pressure.

Where valves tend to stick, some engineers have recommended allowing considerable clearance between the stem and its guide bushing. Such procedure is not recommended here because if there is a tendency to stick due to gumming action the enlarged clearance would fill up with carbon in a short time, notwithstanding the enlargement.

Use of very heavy fuel oil accelerates depositing action because of the unburned residue that may be carried in a finely divided state in the exhaust gases and strike against that portion of the exhaust-valve stem which, when the valve is closed, is enclosed by the guide. If the sticking is due to warping caused by unequal heating, remedy for this should be applied promptly. Excessive clearance permits of distorted seating and leads to rapid wear of the valve seat.

REMOVE GUMMY DEPOSIT WITH KEROSENE

Kerosene, alone, should be used to remove gummy deposit from stuck valves. Lubricating oil may be used on inlet-valve stems but should not be used on exhaust valve stems. If the exhaust valves tend to stick on starting up, kerosene should be applied just before stopping. If this is not sufficient, the valves should be treated with kerosene and worked with a bar for a short time after starting. Such valves always should be tried with a bar before starting up.

Cleaning a valve and its cage for inspection, after removal from the cylinder, may best be accomplished by first soaking in kerosene then rubbing with warm sawdust using a cloth for protecting the hands and finishing with a clean piece of cloth. Both valve and its seat should be examined for fine heat cracks that may develop into leaks.

REPAIR SEATS BEFORE THEY ARE SCORED BADLY

Valve seats should never be allowed to become badly worn; high exhaust temperatures and loss of compression are indications of improper seating. Inspection and regrinding should be frequent enough to avoid need of much grinding which not only lowers the height of the valve, necessitating readjustment of its setting, but consumes considerable time. Only a limited amount of heavy grinding can be done before corrections must be made in the valve connections, because, as the valve becomes thinner and the seat deeper, the range of adjustment of cam roller clearance is reduced.

If the valve seat is badly scored or pitted, it should be trued up before being ground in place. This may be done by preparing a cutter of tool steel, shaped as the valve head but fluted with many teeth on its face and hardened and tempered in the usual manner. This reamer can be operated by means of a breast drill, if a portable drill is not available.

Repeated grinding eventually will form a shoulder on the seat outside the valve. This should be removed either by cutting off the end of the valve cage or seat or by cutting off the shoulder in line with the valve seat.

Valve seats in valve cages may be trued up in an engine-turning lathe by fitting an arbor through the valve stem guides, driving being done by a dog fastened to the lower and rough part of the casting and using a compound rest which may be set at such an angle as to feed the tool across the face properly. If no compound rest is available, a flat-faced tool may be set at the proper angle and fed directly, making a full width cut.

This is liable to cause chattering which may be avoided by use of a steady rest.

Valve Machining Methods

Valves that have become badly worn or pitted should likewise be machined before grinding, as attempting to remove deep pits or grooves by grinding tends to round the surface and aggravate the condition. If the valve is to be turned off in a lathe, it is best first to remove hard parts with a fine file. Grinding the face by means of an emery wheel attachment, set at the proper angle on a lathe is, however, a better method as this will take care of the hard spots without preliminary removal of such imperfections and will produce a smoother surface.

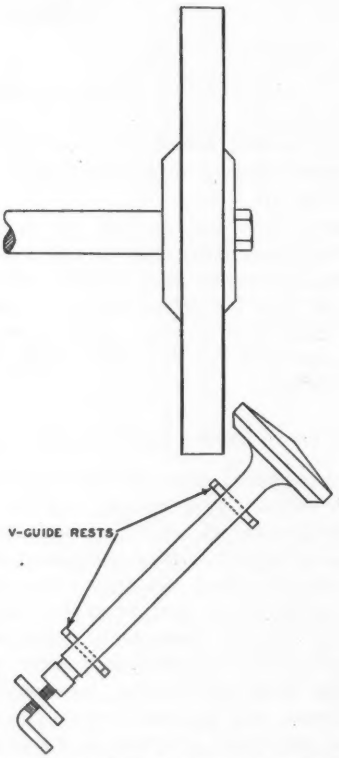


FIG. 1. EXHAUST VALVE FACED ON SIDE OF EMERY WHEEL

Grinding on the side of an emery wheel, although not as good a method of trueing the surface, presents a simple expedient that usually is available in any plant. This method of grinding is accomplished as shown in Fig. 1. The valve is rotated by hand in V-guides and fed up to an adjustable stop as it is ground.

A fairly soft wheel is preferred for this purpose because a hard wheel will not wear away fast enough to keep sharp on a rounded surface. The wheel should rotate downward at the point of contact to protect the operator from the sparks and the valve rotated in the opposite direction. Facing off a valve, before regrinding it, even though it is not in bad condition, is advisable since it saves grinding away the seat unnecessarily and keeps the seat straight. The angle of the valve and seat as refinished should be checked by use of a 45-deg. center gage.

Grinding in place should be resorted to only when the valve seat has a true enough machined surface to secure sufficiently tight seating with relatively little grinding. It should not be necessary to use a coarse grade of abrasive but if this is used for roughing work, the valve and seat should be cleaned carefully by washing them in kerosene or gasoline before the finishing grade of abrasive is used.

It is best to use a single grade of fine grinding compound and finish by grinding with fuel oil to make the surface dense. A mixture of flour emery or carborundum with oil or vaseline may serve as an abrasive material but there are many brands of grinding paste on the market that serve even better. Those that mix with water usually are fast-cutting and will not cut grooves. In this case the surface may be polished by finishing with water alone.

Grinding Apparatus and Procedure

Grinding in place is best accomplished by use of a device such as illustrated in Fig. 2. The valve spring

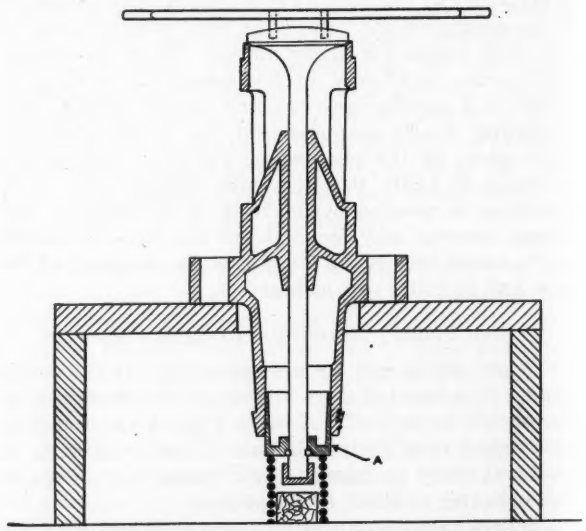


FIG. 2. GRINDING RIG FOR ENGINE VALVES LIFTS VALVES AUTOMATICALLY TO DISTRIBUTE ABRASIVE

is replaced by a light spring placed between the floor and the bottom of the collar A. When the valve seat is integral with the cylinder the light spring may be interposed between the valve head and the valve-seat body. This spring raises the valve slightly when the downward pressure exerted by the operator in grinding is released, thus permitting the abrasive material to be distributed evenly over the surface to be ground. If this is not done the abrasive material forms at the edges, only, causing the valve seat to be ground concave.

Grinding action should be oscillating, rotating the valve back and forth through a quadrant, while pressing down upon its seat, for a short time then changing to another quadrant, continuing the progression around until the grinding is completed and releasing the pressure momentarily at intervals to distribute the grinding paste. After completion of the grinding process, the parts should be cleaned thoroughly. A single grain of emery becoming lodged between the valve and its seat may cause considerable trouble during the operation of the engine.

Frequent regrinding and refacing tend to increase the seat-face width which reduces the unit bearing pressure hence increases the tendency to leak. Narrow faces having higher bearing pressure tend to keep the scale, which may form, thin and evenly distributed but narrow faces will wear away too rapidly, also a leakage may be started across a narrow face quicker than over a wider one. A width of $\frac{1}{16}$ in. is ample.

Care of Valve Springs

Where valve springs are located in pockets exposed at the top, dirt and oil accumulate at their lower ends and becoming quite hot, if the exhaust valve is not water cooled, may gum up and harden, interfering with proper action. Every time a valve is removed, therefore, the spring should be cleaned thoroughly before replacing it.

Valve chattering is caused by the use of springs that are too light. Continuous chattering results in crystallization of the valve stem and eventual fracture with attendant damage to the cylinder when the valve head drops into it. Weak springs may also reduce the volumetric efficiency of the engine by failing to permit the cylinder to receive a full charge of air, hence reducing proportionately the power capacity of the engine.

Tests for Tightness

Tightness after regrinding may be checked by pencil marks drawn across the seat at many points and rubbing the valve on its seat. Tests are best made by use of kerosene or compressed air. In the former, kerosene is poured in above the valve while it is seated until a depth of about an inch above the valve is reached. If there is no drip below, the valve is tight.

In the compressed-air method, the air is admitted into the cylinder when the engine is exactly on dead center. With the exhaust and inlet elbows removed and the starting air turned on, leaks will be detected by the hissing sound produced or by a burning match moved around the contours of the valves.

Grinding valves consumes considerable time hence valve repairs may be procrastinated unless valve cages are employed which permits replacing a removed cage with a spare one with little loss of running time and the repair may be made at any convenient time. The investment in such spare parts as valves and cages is well warranted. Lack of proper attention leads to short life of engine valves and cages. The life of a valve is short after it has started to leak.

Mercury-Vapor Plant for Schenectady

In a new power plant to be built at Schenectady, N. Y., a 20,000-kw. mercury-vapor turbine generator is to be installed that will be outstanding in several respects, according to an announcement by Burton L. Delack, manager of the Schenectady Works of the General Electric Co. It will be the first outdoor steam plant and one of the few power plants to have coördinated industrial requirements and utility sources of power. The mercury-vapor turbine will be twice as large as the unit in service at the South Meadow station of the Hartford Electric Light Co.

This new generating station, which will be leased and operated by the New York Power & Light Corp., will supply electricity for the power company's transmission system and steam for use in the G. E. factory.

One of the present steam generating plants of the company, near the front end of the plant, will no longer be used; its 20 old boilers will be dismantled. Steam for the operation of the non-condensing steam turbine in the building will be supplied from the new power station, conveyed there in pipes in a reënforced concrete tunnel more than three-fifths of a mile long. The other generating station within the General Electric works, which will be connected with the new station by a tunnel a few hundred feet long, will be retained for some years to come.

In addition to the 20,000-kw. mercury boiler and turbine, the new outdoor station will include a steam boiler to supply 300,000 lb. of steam an hour, in addition to the by-product output of 330,000 lb. an hour from the mercury condenser, for process, heating and testing steam in the G. E. works.

Design and erection of the new plant are being handled by the Construction Engineering department of the General Electric Co., of which A. R. Smith is in charge, with engineers of Stone & Webster and of the New York Power & Light Corp. in advisory capacity.

Details of the Schenectady Installation

For the Schenectady installation the mercury boiler drums will be longer than those of the 10,000-kw. equipment at Hartford, but the furnace width will be no greater. The design of the unit was based on generating 20,000 kw. from the mercury turbine and 240,000 lb. of steam an hour made by condensing mercury (the additional 90,000 lb. of the 330,000 lb. already referred to is obtained from the water walls). The doubling of the Hartford capacity will be obtained by increasing the mercury pressure to 125 lb. gage and by installing mercury heating surface on the upper portion of the furnace walls. By thus protecting the furnace walls, the heat liberated in the furnace can be greatly increased over that at Hartford, where the furnace walls are air-cooled. Moreover, the combustion air can be preheated to a higher temperature than was considered desirable with the Hartford furnace, therefore, a low flue-gas temperature to the stack can be obtained without the use of a water economizer. This will permit a greater application of regenerative feed heating with the steam cycle in case condensing steam turbines are used.

When pulverized fuel is burned, the lower portion of the furnace walls should for the present be protected by water heating surface. The fuel economy will be somewhat impaired with this arrangement of furnace as additional fuel is needed to generate steam directly in the furnace walls. Further experience is needed before the entire furnace walls can be protected with mercury heating surface.

With a load of 20,000 kw. on the mercury turbine and with the power developed from the 240,000 lb. of steam generated at 400 lb. pressure and 350 deg. F. by condensing the mercury vapor, the expected fuel rate will be 8800 B.t.u. per net kilowatt-hour. With water cooling in the lower part of the furnace, the fuel rate will be from 9100 to 9500 B.t.u. per net kilowatt-hour, depending on the amount of steam generated directly in the water-cooled furnace walls.

Design of Secondary Distribution Systems

PART I. ECONOMIC SECONDARY DESIGN FOR A SINGLE-PHASE SYSTEM SERVING A CITY OF ABOUT 120,000.

By V. W. Palen

THIS ARTICLE deals specifically with the electrical and economic phases of secondary design as they concern a power company serving a city of approximately 120,000 inhabitants. At the outset it was decided that a 50-kv-a. single-phase transformer was the largest practical to hang on a pole. This decision therefore, limits the load density to 12½ kv-a. per block in the case of two block (1100 ft.) transformer separation. Likewise, it limits the load density to 25 kv-a. per block in the case of one block (550 ft.) transformer separation.

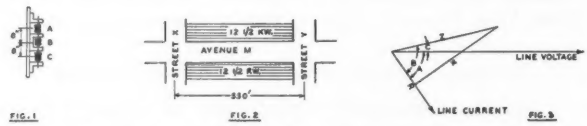


FIG. 1. RACK USED TO SUPPORT CONDUCTORS
FIG. 2. THE MAXIMUM LOAD CONDITIONS
FIG. 3. VECTOR DIAGRAM REPRESENTING CASE FOR NO. 0000 WIRE AND A LOAD POWER FACTOR OF 90 PER CENT

In the city under consideration, the standard city block is 550 ft. in length and the company supplying service has standardized on No. 4, No. 2, No. 00, and No. 0000 for secondary wire, No. 0000 being used but rarely. The secondary wires are generally supported on racks shown in Fig. 1.

With the foregoing in mind, we further assume that the case shown in Fig. 2 will be our maximum load condition, which is obviously 25 kv-a. per city block. Since the neutral wire "B" (Fig. 1) under balanced load conditions carries no current, we may compute or select from tables our reactance values for the wire sizes on the basis of 16-in. separation.

In order to approach normal conditions more correctly, we assume a 90 per cent load power factor and by the following method determine a factor by which to multiply the impedance of the various wire sizes to obtain what we have termed an "effective impedance."

Figure 3, let us say, represents the case of No. 0000 wire with a load power factor of 90 per cent—

Then Cosine = 0.90

And from the tables we find A = 25° 50′

But we know $\text{Cosine B} = \frac{R}{Z}$

And from the Tables we find R = 0.2703, and X = 0.531 (per mile)

Therefore: $\frac{R}{Z} = \frac{0.2703}{\sqrt{(0.531)^2 + (0.270)^2}} = \frac{0.2703}{0.597}$

= 0.453 = Cosine B

From tables we find B = 63°4′

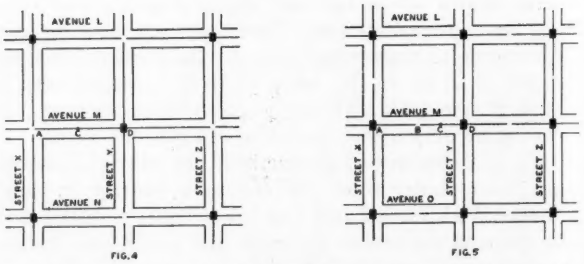
Subtracting, we find B — A = 37°14′ = Angle L

We therefore multiply impedance of wire (0.597) by Cos L (0.79618) to get effective impedance, thus:

Eff (z) = (0.79618) (0.597) = 0.475 ohms/mile = 0.0899 ohms/1000 ft.

Table I then is a table of "R," "X," "Z" and Eff "Z" for the four-wire sizes under consideration.

In Fig. 4 there is an expanded plan of a typical secondary having transformers spaced every two blocks along Avenues "L," "M," and "O." Each transformer will have to carry two city blocks of load along the avenues, plus two city blocks of load along streets "X" and "Y". For practical purposes, we assume a uniformly distributed load from "A" to "D" and consider it concentrated at "C" in our computations. Then for our



FIGS. 4 AND 5. DIAGRAM SHOWING DETAILS OF SECONDARY SYSTEM

maximum conditions we may say there is 12½ kv-a. at "C".

$$I = \frac{12{,}500}{220} = 56.75 \text{ amp. per secondary leg}$$

In passing, it is interesting to note that the Underwriters require No. 4 (or larger) rubber covered wire to carry this current.

Since CD = ½ AD

CD = ½ (550) = 275 ft.

$$\text{IZ drop} = \frac{2\,(275)\,ZI}{1000}$$

Where Z = (Eff Z) per 1000 ft.

If we allow a 2-v. drop on 110 v., which is equivalent to a 4-v. drop on 220 v., then:

$4 = 31.2\ Z$

$$Z = \frac{4}{31.2} = 0.1281 \text{ ohms per 1000 ft.}$$

From Table I we find No. 2 has an (Eff Z) of 0.1931 per 1000 ft., and No. 00 has an (Eff Z) of 0.1180 per

1000 ft. It is, therefore, necessary to use No. 00 in order to guarantee that the drop of 2 v. on 110 be not exceeded.

Our next consideration is to place the transformers one city block apart, as shown in Fig. 5. From this we see that each transformer must carry one city block of load along the Avenues "L", "M" and "O", plus one city block of load along the Streets "X", "Y", etc. Since our maximum load now becomes 25 kv-a. per block = 12.5 kv-a. per ½ block,

$$I = \frac{12{,}500}{220} = 56.75 \text{ amp. per secondary leg}$$

It is interesting again to note here that the Underwriters require No. 4 or larger rubber covered wire to carry this current.

TABLE I. VALUES OF R, X, Z AND EFF. Z

Wire Size	Per 1000 Feet			
	R	X	Z	Eff. Z (90% P.F. Load)
4/0	.0512	.1005	.1128	.0899
2/0	.0812	.1059	.1335	.1180
#2	.1593	.1140	.1960	.1931
#4	.2533	.1190	.2800	.2800

Now CD = ½ BD = ½ (275) = 137½ ft.

$$\text{IZ Drop} = \frac{2\,(137\tfrac{1}{2})\,ZI}{1000} \quad \text{Where Z = Eff Z per 1000 ft.}$$

$$= \frac{275 \times 56.75}{1000}\,Z = 15.60$$

$$\text{Then: } Z = \frac{4}{15.60} = 0.256 \text{ ohms per 1000 ft.}$$

From Table I we find No. 4 has an impedance of 0.2800 ohms per 1000 ft. and No. 2 wire has an impedance of 0.1931 ohms per 1000 ft. Therefore No. 2 or larger will be required to guarantee that the drop of 2 v. on 110 v. be not exceeded.

Table II is a table of relative costs of transformers; Table III is a table of relative costs of wire (these values will vary with the various localities and companies); Table IV shows core and copper losses. Here it was assumed that full load existed on the transformer for 4 hr. a day. As an example, take a 15-kv-a. transformer:

Core loss = 105 × 24 = 2520 watt/hr. = 2.52 kw-hr.

Copper loss = 233 × 4 = 932 watt/hr. = 0.932 kw-hr.

All day loss = 2.52 × 0.932 = 3.452 kw-hr.

Total power delivered = 15 × 4 = 60 kw-hr.

$$\text{All day EFF} = \frac{60}{63.452} = 94.7 \text{ per cent}$$

The cost per day for transformer losses is figured, therefore, for a 75-kv-a. transformer, as follows:

For two-block transformer spacing, since each transformer feeds four blocks of secondary, ¼ of the total capacity is required per block.

With a 50-kv-a. transformer $\frac{50}{4}$ = 12.5 kv-a. per block

All-day losses on 50-kv-a. transformer from Table IV are 8.18

Therefore, $\frac{8.18}{4} \times \$0.01 = \$0.02045$ per day per block of secondary

In the case of one block transformer spacing, since each transformer feeds two blocks of secondary, ½ of the total capacity is required per block; thus:

With a 50-kv-a. transformer $\frac{50}{2}$ = 25 kv-a. per block,

$\frac{8.18}{2} \times \$0.01 = \$0.0409$ per day per block of secondary.

Figure 6 is a chart plotted between wire size and kv-a. per city block. The arrows indicate the limits of the various transformer sizes and the curves show the limits of the various sizes for one and two-block transformer spacing. These curves are on the basis of a maximum drop of 2 v. on 110 v. or 4 v. on 220 v.

TABLE II. RELATIVE COSTS OF TRANSFORMERS

Size of Transformer	1½	3	5	7½	10	15	25	37½	50	75	100
Cost ($)	25	38	61	78	97	129	149	251	309	387	424

TABLE III. RELATIVE COSTS OF WIRE

Size of Wire	6	4	2	00	0000	500,000
Cost ($) per 1000 ft.	18	26	41	80	122	303

TABLE IV. CORE AND COPPER LOSSES

Transformer Size	Core	Copper	All Day Losses	All Day Eff (%)
1½	25 W	37 W	.748 KWH	89.
3	34 W	70 W	1.096 KWH	91.75
5	45 W	102 W	1.488 KWH	93.0
7½	62 W	137 W	2.038 KWH	93.5
10	80 W	163 W	2.572 KWH	94.
15	105 W	233 W	3.452 KWH	94.7
25	147 W	351 W	4.93 KWH	95.4
37½	194 W	460 W	6.50 KWH	95.9
50	240 W	605 W	8.18 KWH	96.0
75	360 W	859 W	12.09 KWH	96.2

Figure 7 shows the method of serving the transformers with primary for two-block spacing. In this case there are 53 blocks of 3 phase, which equals 159 blocks of single conductor plus 57 blocks of 1 phase, which equals 114 blocks of single conductor.

Since there are 84 transformers served in this area:

$$\frac{114 \times 159}{84} = 3.25 \text{ blocks single conductor per transformer.}$$

But each transformer serves four blocks of secondary, therefore:

$$\frac{3.25}{4} = 0.8125 \text{ blocks single conductor per block of secondary.}$$

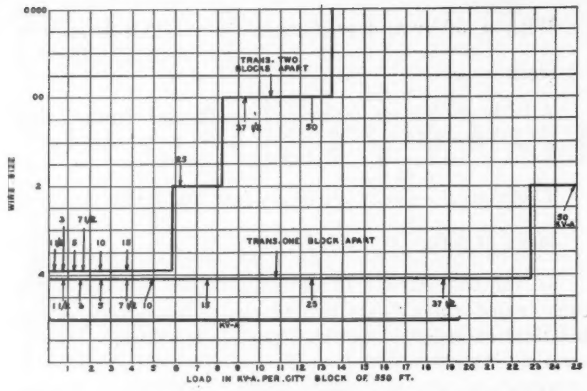


FIG. 6. CHART PLOTTED BETWEEN WIRE SIZE AND KV-A. PER CITY BLOCK

If we use No. 2 primary, costing \$41 per 1000 ft., fixed charges amount to:

$$\frac{0.8125 \times 550}{1000} \times \$41 \times \frac{0.15}{365} = \$0.00754 \text{ per day}$$

per block of secondary.

Figure 8 shows the method of serving the transformers with primary for one block spacing. In this case there are 54 blocks of 3 phase, which equals 162 blocks of single conductor plus 112 blocks of 1 phase, which equals 224 blocks of single conductor. Since there are 168 transformers served in this area:

$$\frac{162 + 224}{168} = 2.30 \text{ blocks single conductor per transformer.}$$

But each transformer serves two blocks of secondary, therefore:

$$\frac{2.30}{2} = 1.15 \text{ blocks single conductor per block of secondary.}$$

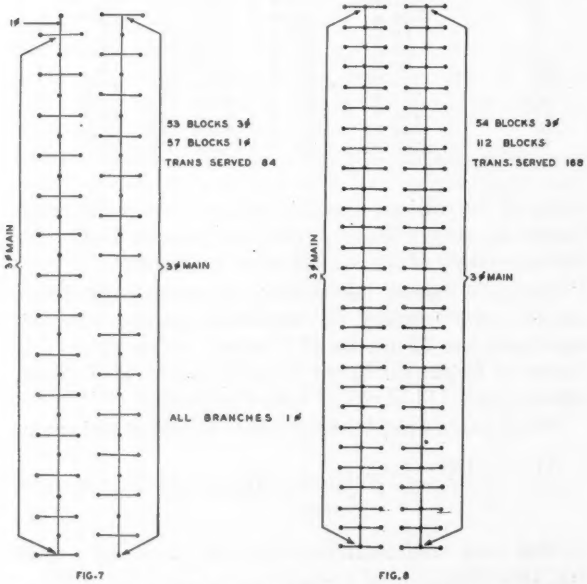


FIG. 7. METHOD OF SERVING THE TRANSFORMERS WITH PRIMARY FOR TWO BLOCK SPACING

FIG. 8. METHOD OF SERVING TRANSFORMERS WITH PRIMARY FOR 1 BLOCK SPACING

Again using No. 2 primary at \$41 per 1000 ft., we find that the fixed charges amount to:

\$0.01068 per day per block of secondary.

It can be shown that for a uniformly loaded wire the losses amount to:

$$\frac{I^2 \, r \, l}{3}$$

and for two wires:

$$\frac{2 \, I^2 \, R}{3}$$

Where I = Maximum current in wire
R = Total resistance of one wire.

For two block transformer spacing R = resistance of 550 ft. of wire and I may be put in terms of kv-a. and assuming \$0.01 per kw-hr. for energy:

Cost per day for I^2 R losses in secondary =

$$\frac{\text{kv-a.}^2 \text{ (r per 1000 ft.)}}{3300}$$

Thus for 12.5 kv-a. per block load (from Fig. 6) use No. 00

$$\text{losses} = \frac{(12.5)^2 \ (0.0812)}{3300} = \$0.00384 \text{ per day per block of secondary.}$$

For one-block transformer spacing R = resistance of 275 ft. of wire and I may be put in terms of kv-a. and assuming \$0.01 per kw-hr. for energy:

Cost per day for I^2 R losses in secondary =

$$\frac{\text{kv-a.}^2 \text{ (r per 1000 ft.)}}{6600}$$

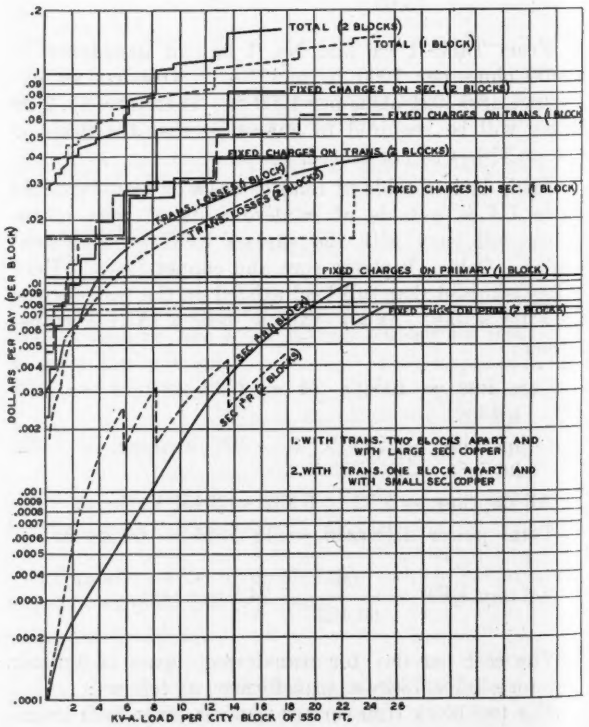

TOTAL (2 BLOCKS)
TOTAL (1 BLOCK)
FIXED CHARGES ON SEC. (2 BLOCKS)
FIXED CHARGES ON TRANS. (1 BLOCK)
FIXED CHARGES ON TRANS. (2 BLOCKS)
TRANS. LOSSES (1 BLOCK)
TRANS. LOSSES (2 BLOCKS)
FIXED CHARGES ON SEC. (1 BLOCK)
FIXED CHARGES ON PRIMARY (1 BLOCK)
SEC. LOSSES (1 BLOCK)
SEC. LOSSES (2 BLOCKS)
1. WITH TRANS. TWO BLOCKS APART AND WITH LARGE SEC. COPPER
2. WITH TRANS. ONE BLOCK APART AND WITH SMALL SEC. COPPER
DOLLARS PER DAY (PER BLOCK)
KV-A. LOAD PER CITY BLOCK OF 550 FT.

FIG. 9. DIFFERENCE IN COST OF SUPPLYING VARIOUS LOADS FOR MAXIMUM DROP OF 2 V. ON 110

Thus for 25 kv-a. per block load, each transformer carries 12.5 kv-a., and from Fig. 6 use No. 2.

$$\text{Losses} = \frac{(12.5)^2\ (0.1593)}{6600} = \$0.00377 \text{ per day per } \tfrac{1}{2} \text{ block of secondary.}$$

Since there are two secondaries in a block:

Losses = 2 × $0.00377 = $0.00754 per day per block of secondary.

The fixed charges on transformers for two-block spacing are figured in the following manner:

Since each transformer feeds four blocks of secondary, ¼ of transformer cost is charged to each block of secondary; thus, for a 50-kv-a. transformer which (from Fig. 8) costs $309.

$$\frac{\$309 \times 0.15}{4 \times 365} = \$0.03175 \text{ per day per block of secondary.}$$

The fixed charges on transformers for one-block spacing are figured in the following manner:

Since each transformer feeds two blocks of secondary, ½ of transformer cost is charged to each block of secondary. Thus, for a 50-kv-a. transformer which (from Fig. 8) costs $309—

$$\frac{\$309 \times 0.15}{2 \times 365} = \$0.0635 \text{ per day per block of secondary.}$$

The fixed charges on wire are figured the same way for both one and two-block transformer separation. Thus, for No. 0000:

Length of secondary = 550 ft.

Length of single conductor = 3 × 550 ft. = 1650 ft.

Cost of No. 0000 = $122 per 1000 ft. (from Fig. 9).

$$\frac{0.15 \times \$122 \times 1650}{365 \times 1000} = \$0.08275 \text{ per day per block of secondary.}$$

By the methods outlined in the foregoing, therefore, Fig. 9 was developed. This chart shows costs of secondary I^2R and transformer losses; fixed charges on primary, secondary and transformers, and totals for one and two-block transformer separations for various loads per city block.

In examining the total curves, we note that they cross at 6.2 kv-a. per city block and that for loads less than 6.2 kv-a. per city block two-block transformer spacing is most economical. Likewise, for loads greater than 6.2 kv-a. per city block, one-block transformer spacing is most economical.

Again studying Fig. 6, we come to the conclusion that with conditions as shown herein, apparently the most practical program to follow is as follows:

Install no larger than No. 2 secondary.

When load and voltage conditions necessitate, change from two-block transformer separation to one-block transformer separation.

SYNTHETIC AMMONIA processes require considerable amounts of power because of the high pressures involved. A mixture of hydrogen and nitrogen is subjected to high pressures and temperatures which range from 1100 to 14,000 lb. and 750 to 1150 deg. F., depending upon the process.

Hartford Mercury Turbine Data

IN VIEW of the announcement of the large mercury-vapor turbine-generator which will be installed in Schenectady, the following data regarding the performance of the Hartford turbine in 1930 is of interest. The Hartford unit has been in continuous operation since February 4, except for occasional week-ends and during nine days in May when minor changes were made. During the nine months from February to October, inclusive, the performance of the unit was as follows:

Coal burned	69,187,540 lb.
Water evaporated	572,415,000 lb.
Output mercury turbine	42,297,000 kw-hr.
Equivalent output from steam	56,910,660 kw-hr.
Total station service	1,924,390 kw-hr.
Total net output	97,283,270 kw-hr.
Coal rate on total net output	0.712 lb./kw-hr.
Hours in service	5,030
Use factor	76.6
Capacity factor	64.6

The availability factor of the equipment was as follows:

	Feb. 4 to Oct. 31	July 13 to Oct. 31
Mercury apparatus only	96.6	99.5
Mercury plant complete	83.5	88.6

Kilowatt-hours generated would have been much greater except for excess water power available during the early months of the year and also during nights and week-ends. The tabulation given below shows average daily operation records of the equipment under commercial conditions at full load:

Load on mercury turbine	10,000 kw.
Speed of mercury turbine	720 r.p.m.
Steam produced per hour	129,000 lb.
Feedwater temperature to economizer	214 deg. F.
Feedwater temperature to mercury condenser	275 deg. F.
Steam pressure	280 lb. ga.
Steam temperature	735 deg. F.
Mercury vapor pressure at turbine	70 lb. ga.
Mercury vapor temperature at turbine	884 deg. F.
Mercury condenser vacuum	28.25 in. Hg.
Mercury condenser vacuum temperature	447 deg. F.
Temperature of air at burner box	460 deg. F.
Temperature of gas to stack	335 deg. F.
Coal burned per hour	15,800 lb.
Heat in coal as fired	14,300 B.t.u./lb.
CO_2 in flue gas	14.0 per cent

Electric auxiliary power, amounting to some 415 kw., includes water-feed pump, induced and forced-draft fan, coal-pulverizing units, generator excitation and so on. Commercial operation over a period of several days with a steady load of 9500 kw. on the mercury-turbine generator gave a net economy of 9800 B.t.u. per kw-hr. and over a period of nine months 10,180 B.t.u. per kw-hr. An improvement in economy can be made, it is stated, when steam is generated at the higher pressure of 400 lb. ga. and the feedwater heated to a greater extent by extracted steam. Ease in operating this apparatus was fully demonstrated in 1930, according to the announcement, and experience during the year indicated that maintenance costs will be less than with standard steam plants.

Westinghouse Increases Capacity of Its High Power Laboratory

By W. R. Woodward and H. W. Tenny*

DEMANDS OF POWER SYSTEMS for circuit breakers that will rupture unusually large currents have necessitated the extension of the facilities of the a.c. High Power Laboratory of the Westinghouse Electric and Manufacturing Co. by the addition of a new generator rated at 60,000 kv-a. which has increased the capacity of the laboratory to 100,000 kv-a.

The original installation of the a.c. High Power Laboratory (now known as station No. 1) was placed in operation in November, 1925, with a total generation capacity of 40,000 kv-a. The plant was extended in 1928 to high voltage testing ranging from 22,000 to 220,000 v. by the addition of a 100,000-kv-a. transformer bank. Now with the addition of the new generator, tests of even greater severity will be given breakers in order that still better ones may be built that will be suitable for the largest power systems.

The new generator operates at 514 r.p.m. and has special characteristics to make it suitable for this testing service. The reactance of the generator is very low compared to commercial machines and the short circuit ratio is very high so that high momentary current can be produced and sustained.

This single generator (in combination with its special exciter) will produce and sustain a short circuit of more than 600,000 kv-a. for 3 sec., and the combined station will produce a short circuit of over 1,000,000 kv-a. A test approximately equivalent to that of a three-phase short circuit of 1,700,000 kv-a. can be made by testing one pole of a 3-phase breaker across the generator terminals.

The additional facilities are installed in a new all-welded building approximately 70 by 140 ft. which houses the generator, motor, exciter, switchgear, reactors, resistors and details.

Either 3-phase or single-phase tests may be made on these stations. The vibration of a generator is extremely severe when testing single phase and to relieve stresses on the foundation and structure the new generator is mounted on very heavy springs, permitting a slight rotative movement of the generator frame and absorbing the torque in the inertia of the generator frame. The generator rotor is of the salient-pole type having very heavy damper windings suitable for single-phase testing.

For limiting the short circuit current obtained on test without reduction in voltage, a complete set of reactors is provided. A three-phase bank of resistors is also provided by means of which the power factor of the current can be adjusted. These resistors are made of non-magnetic material as it was discovered that the ordinary cast iron grids normally used for such service produced a serious distortion in the wave form of the current due to their magnetic qualities. This wave form distortion occurred at low values of current (that is, when the current is passing through the zero point) and was considered to be of sufficient importance to justify the use of non-magnetic material. Oscillograms of the wave form on these resistors show them to be entirely free of such wave form distortions.

Oscillograph Equipment

Extensive use is made of oscillographs, two nine-element instruments being provided for the new station and a total of nine elements being in use in the old station. The entire plant is electrically controlled and the operation of the plant is automatic during a test cycle,

*Both of Westinghouse Electric and Mfg. Co.

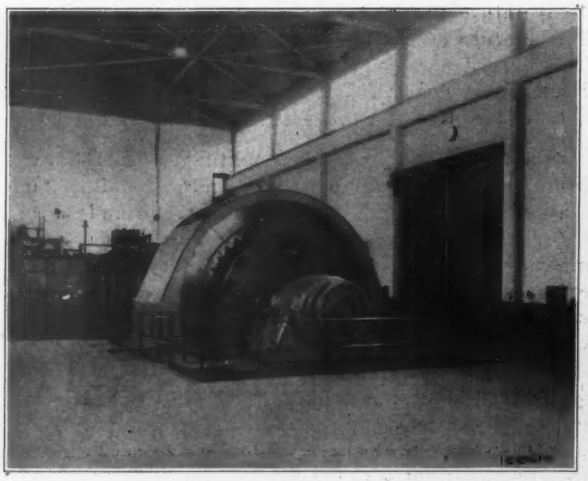


FIG. 1. NEW 60,000-KW. GENERATOR WHICH WILL PRODUCE AND SUSTAIN A SHORT CIRCUIT CURRENT OF MORE THAN 600,000 KV-A. FOR 3 SECONDS

FIG. 2. CONTROL BUILDING IN WHICH CONTROL AND RECORDING EQUIPMENT IS INSTALLED

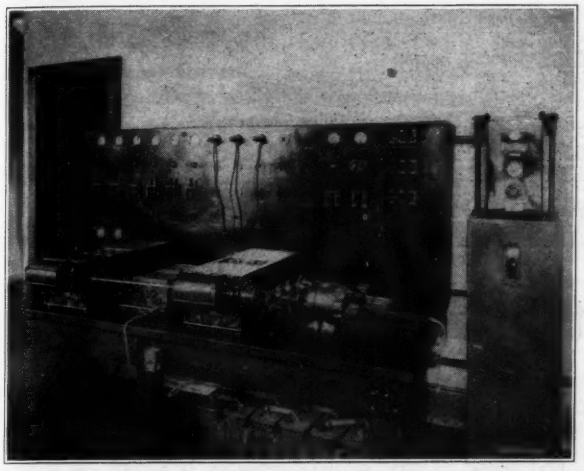


FIG. 3. TWO 9-ELEMENT PORTABLE OSCILLOGRAPHS IN THE OPERATING ROOM. THESE CAN BE MECHANICALLY CONNECTED TO MAKE 18 RECORDS SIMULTANEOUSLY

the operations being controlled by a motor-driven cycle drum which controls the various relays in proper sequence and time relation to carry out the test desired. The entire plant is controlled from a new control station. This is in a two-story building located about 170 ft. in front of the test cells. The first floor is devoted to plant operation, containing the control desk and instruments, oscillographs, auxiliary equipment and dark room facilities. The second floor provides an observation room giving a clear view of all of the test cells and also provides desk space for engineers interested in the test. While this control building is located at a conservative distance from the test cells, use was made of non-shatterable glass in the windows, further to minimize danger from explosions or possible missiles thrown from equipment under test. The yard and test cells are very fully illuminated so that testing can proceed at night when desirable.

In the operating room of the control building, a special table is provided for the oscillograph instruments. Two 9-element portable instruments are provided and these can be mechanically connected together so that 18 completely synchronized records can be made simultaneously. On the rear of this table is mounted an

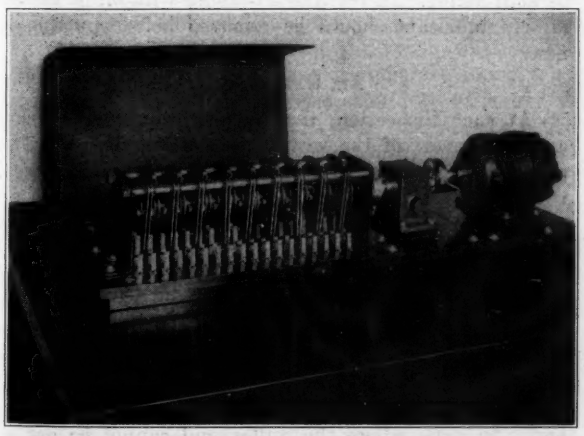


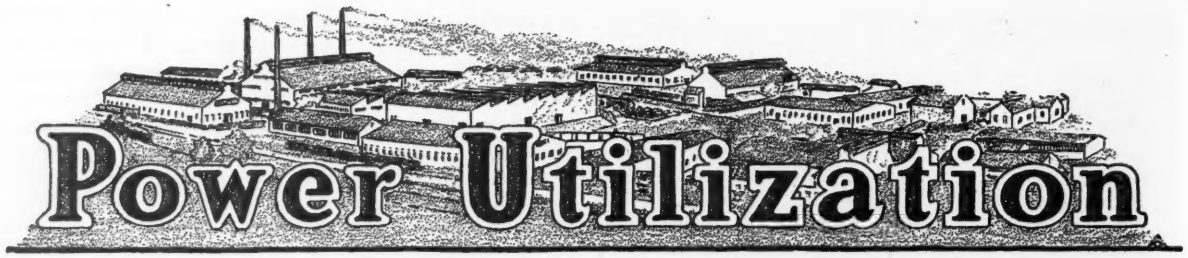
FIG. 4. THESE CAM-OPERATED SWITCHES CONTROL THE SEQUENCE OF OPERATIONS

instrument and terminal panel. All leads from the test cells terminate in special receptacles so that any circuit may be connected to the oscillograph elements without delay. Leads from the current transformer secondaries are automatically short-circuited before a plug can be withdrawn. The table itself is located near the control desk from which the plant operator controls all of the generator station equipment by remote control. With the station operator and the oscillograph engineer located together, mistakes in communicating directions are avoided. Furthermore, it is possible for each to assure himself without delay or confusion that the other is prepared.

The most important records in high power testing are, of course, the test circuit currents and voltages. For this new laboratory a special study was made of methods of measuring high currents to make certain that the greatest possible accuracy consistent with safety to laboratory engineers would be obtained. Current transformers were decided upon for this laboratory because with them it is possible to make grounded or ungrounded tests at will without making special provisions for insulating all of the oscillograph equipment. The special resistance and reactance units provided for limiting the short circuit currents can be connected either between the test breaker and the 60,000-kv-a. generator or between the breaker under test and the ground. Under the second condition, the breaker will not be at ground potential, but at some value above ground which is equivalent to the drop across the reactance and resistance in the circuit. Here again the insulation provided by the current transformer is essential. These new current transformers are so designed that the iron will not saturate at the highest currents, which are in the order of 110,000 amp. They have a ratio of 2500 to 5, which means that at the higher currents, the secondary currents will be in the order of 200 amp. It was felt that the conductors required to carry this current to shunts on the oscillograph table in the control house would be too large and consequently special inductive shunts are located at the current transformers in the generating station. The inductive shunts were used so that the proper range of currents could be obtained for operating the watt elements in the oscillograph throughout the complete range of currents which can be obtained in the test circuit. The time constant of each special shunt is adjusted to be equivalent to that of the circuit from the shunt to the oscillograph, so that the current in the oscillograph element will be in phase with the current in the test circuit.

NAVY DEPARTMENT specifications for leather belting call for oak tanning by the slow process for 6 to 8 mo., chemical processes not being permitted, all belting to be cut not more than 15 in. from the backbone nor more than 48 in. from the tail toward the shoulders. Belts 8 in. wide or over must include the backbone. All 48-in. leather strips must be stretched 6 in. lengthwise and not exceed 54 in. in length after stretching. Centers and sides are to be stretched separately. Leather must not crack on the grain side when doubled strongly by hand, grain side out.

DETERMINATION of power plant performance demands the establishment of definite standards.



Electric Motor Operation and Maintenance

PART I. ROUTINE INSPECTION OF AIR GAP, BEARINGS, BRUSHES, CONTROLLERS AND OTHER PARTS HELPS TO REDUCE COSTS. BY GRADY H. EMERSON

BECAUSE motors are the chief medium for changing electrical power to mechanical power, they will come in for a large share of any discussion of proper use of electrical power. Operating normal at full or near full load and with proper care, the motor will use the electrical energy delivered to it most economically. If this same motor is operated at low power factor, lightly loaded or with worn bearings or other ailments to which motors may be subject, it will undoubtedly misuse the power delivered to its terminals and it may cause various kinds of trouble with the control equipment. For purchased power the bills will be higher than normal and for generated power the cost per kilowatt-hour will rise. Conditions neglected long enough may become so serious as to result in burn outs or damage to bearings or windings.

In every plant using motors, somebody is detailed to look after them. In small plants, this is likely to be a man handy with machinery or who knows something about electricity and who will include this in his multitude of other duties, the real care being limited to occasional Saturday afternoons or Sundays. In larger plants, a full staff of well trained electricians is maintained with system of maintenance repair and records of the inspections and repairs needed. Proper inspection and what to look for when inspecting is a difficult subject, conditions determining the actual inspection routine. In any case it is essential that some record be kept of inspections and repairs and it is well to check the power which should be used against that which is actually used in order to detect leaks and bad conditions. If power is purchased, the power company's figures may be used. For a plant generating its own power, watt-hour meters should be installed and read regularly.

FREQUENCY OF INSPECTION

Some plants have an inspection period of one week, others two weeks, and a few monthly. Where operation of machinery is intermittent as in machine shops, it would seem that an inspection period of two to four weeks is permissible. In steel plants and foundries, one week should be about right and, for special equipment such as hot metal cranes where the motors get hard service, they should be gone over once or twice each shift. Damp and dusty locations call for one or two inspections each week. If a record of troubles encountered and irregularities found on each inspection is kept and dated, it will soon be possible to devise an inspection suited to the individual plant. In some cases an inspection once in three months may be sufficient where motors are used very little but inspection should be sufficiently frequent to uncover and remedy defects as developed and before they become serious. Obviously, control equipment should be inspected with the same frequency as the motor equipment.

INSPECTION DETAILS FOR A.C. MOTORS

As the induction motor is more common than other types, this will be considered first. The motor is simple in construction, having rotor, stator and bearings, so that inspection should take but a few minutes. Occasionally the frame and bearing pedestals should be gone over to make sure that joints and bolts have not worked loose. The motor should be blown out with dry air at 20 or 30 lb. pressure from either a compressed air system or a portable blower. Some plants prefer a vacuum cleaner as it collects the dust but some blowing is generally necessary to get the dust out of the corners of the windings.

Air ducts in the stator should be kept open and all the dust that has accumulated in the coils and end frames should be removed. If the machinery has sleeve bearings, care should be taken that oil be not blown out of the bearings and into the windings.

Oil level should be checked and, if the bearings are of the grease lubricated type, the grease supply should be kept ample. In refilling a bearing with oil or grease, all old lubricant should be removed before putting in new.

AIR GAP CHECKS

At each inspection, the air gap should be checked and note made of the wear over a given period. This can then be used as a basis so that any abnormal wear will be detected. On high efficiency machines the air gap is very small and in nearly all induction machines runs in the thousandths of an inch. For testing it a number of thickness gages are on the market, having some ten different leaves and these will be satisfactory for almost any type of motor. These gages must be used carefully to avoid misleading results. For a new motor the gap should be measured on all sides and a note made of each reading, preferably from the pulley end. In cases where the pulley end cannot be got at, the other end will have to serve and will be an index

but the bearing will wear more next the drive and wear will usually be shown on the side toward which the belt pulls or the gear thrusts.

After the first gaging, the air gap reading can be taken on the top part between the rotor and stator as there is seldom dirt or dust collected at that point. If for instance, it should be found that on one reading the air gap was 0.006 in. and a week later this should be 0.0065 in., something is wrong because 0.0005 in. wear in one week is too much. Immediate attention should be given to find the trouble because more motors are worn out from bad bearings than from any other cause. In measuring bottom air gap, be sure that no oil or dirt interferes with the gage.

Bearing Wear

When to replace bearings yet get all possible wear is a question hard to decide and depends largely on the amount of time the machine is operated and also on its importance. Obviously, a motor should never be operated when smoke is coming from it whether from the bearings, from the rubbing of the rotor on the stator, or from hot insulation. Bearings should be replaced or repaired before there is any possibility of rubbing of the stator on the rotor and even any serious unbalancing of the air gap between two sides of the rotor will produce uneven pull on the rotor and is likely to result in considerable vibration.

If greased occasionally, ball bearings give little trouble from friction but must be kept in proper adjustment to keep the air gap even. The same applies to roller and other forms of antifriction bearings, which usually have adjustment by screws or shims so that the bearing wear can be taken up over a period of years.

Although considerable time is taken to describe it, the whole inspection will take but a few minutes.

Slip Ring Motor Inspection

Motors of slip ring or wound-rotor type will require a somewhat more extensive inspection but all that has been said in regard to the plain induction motor applies to them. In addition, brushes should be inspected for wear and any that are short replaced. Any found sticking in the holders should be sanded so that they will move freely. Tensions should be tested and adjusted so that they will be about 4 lb. per sq. in. of brush contact, a small spring balance being used every three months. For intermediate inspections, the inspector can usually tell by the feel of the brush whether the tension is about right. If any springs are found with tension burned out, the brushes should be examined to see whether the pig tail shunt is loose either in the brush or at the screw holding it to the brush holder. Unless these things are checked carefully, rings may be burned or sometimes rotor windings may be burned out. The brush springs should not have to carry the current.

If pitting or burning is found on any of the rings, the roughness should be ground down smooth either by the use of a grinding stone or by grinding or turning in a lathe. Unless roughness is too great, the hand grinding stone will serve all purposes until regular overhauling time.

Resistors should be inspected for loose terminal wires and broken grids and the controller for loose terminal wires or lugs and loose fingers, also for pitted fingers and segments. This type of motor has high starting torque and the torque depends upon the condition of its brushes and control equipment. Unless this equipment is kept in good condition, the motor may refuse to start or may operate slowly and heat up or burn out.

Usually slip ring motors have larger air gap than induction motors but this should nevertheless be properly adjusted.

Operators of the slip ring type should be cautioned about leaving the controller handle on starting points of the grid as this will cause them to heat unduly. All pitted controller fingers should be removed and smoothed down, or, if necessary, new ones installed. At the running point of the controller the fingers and segments must always be kept in good condition because at this point all resistance is cut out of the rotor circuit and, if one of these segments makes bad contact or leaves an open circuit, the motor will draw more current than normal, will be inefficient and may heat up dangerously. Also speed will be cut down which becomes an important feature in production output.

Where slip ring motors used for hoist or crane duty show that the resistors are heating too much, either loads are too heavy for the grids or the motor or else grids are not the proper ones for the duty. The Electric Power Club has a card showing the duty of each number grid and these cards may be obtained from almost any motor sales office. Heating of the grids may be caused by a defective motor so that if the grids are correct the motor needs a careful going over.

Synchronous Motor Inspection

Synchronous motors are less complicated than the slip ring but usually require more detailed care in starting and operation. Direct current is required for exciting the rotating field and, unless the motor is used to drive a direct current generator as its main load, it must have direct current from some other source. The air gap may be anything from $\frac{3}{32}$ to $\frac{1}{4}$ in., which is sufficient so that it is unlikely that the rotor will ever drag on the stator.

By varying field excitation the synchronous motor may be used for power factor correction and in any plants where the power factor is low it will usually pay to use such motors on large drives which require but small starting torque, such as air compressors and similar applications. It is inadvisable to install them in a dusty location because the fields may give trouble due to grounds which will usually be noticed by vibration of the machine. With reasonable care these motors give little trouble.

Synchronous motors are usually started as induction motors with a starter similar to the induction motor type, and the field switch is thrown in after the motor is up to speed. Besides the attention necessary on induction motors, inspection of the brush system for supplying field current should be given careful attention to make sure that the brushes have proper contact, are free to move in their holders, that all current-carrying contacts are firm and that slip rings are smooth.

Single-Phase Motors

Other motors used for industrial work are the single-phase and these only in smaller sizes except for railway motors. The single-phase motor is generally self-

starting with some sort of a centrifugal arrangement for cutting out the starting winding when the machine is up to speed.

For the repulsion type, a brush system operates at all times when the motor is running. For all such motors, the brush rigging must be carefully inspected for defects as described in the directions for slip ring motors.

The single-phase motor is considerably affected by low voltage and voltage changes, hence terminal voltage should be kept constant. Unless this is done, the motor will have low efficiency. If the centrifugal switch mechanism fails to operate, the motor will fail to reach its speed and, if allowed to run in this condition, windings will probably be burned out. The switch mechanism should be carefully inspected and kept always in good operating condition.

In the repulsion-induction type, brushes are shifted to change direction of rotation and on the repulsion type the field is arranged so that the motor may be reversed. On some types the stator has to be shifted slightly but, as these motors are not widely used in industrial plants, further attention will not be given to them.

4-Ton Switchboard Moved

No Dismantling or Disconnection Except of Main Leads. By L. E. Beneze

DURING extensive reconstruction in a midwestern industrial plant, it became necessary to move the switchboard shown in Fig. 1, which was 38 ft. long, weighed 4 t. and consisted of 16 panels. Incoming feeders were at the center, four 750,000 cir. mils cables per phase, coming through the floor in conduit to supply 3-phase currents at 220 v. Outgoing lines were 112 in number, of assorted sizes from Nos. 14 to 000 and left the board through a cable duct seen at the top.

This problem fell to the lot of the writer to solve and study was made to see how it could best be handled. Estimate of the time to dismantle and reassemble gave 1200 man-hours, which seemed a lot, so consideration was given to moving the board intact, which was finally decided upon as the better method.

FIG. 1. THE SWITCHBOARD BEFORE MOVING

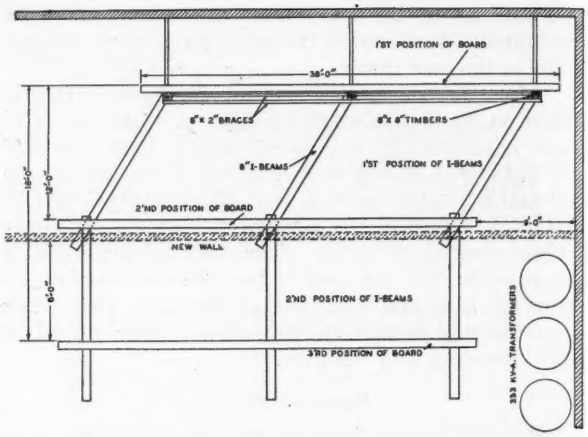


FIG. 2. DETAILS OF BRACING AND MOVEMENT

Work was started by severing cable box, wires and back braces close to the board, tagging both ends of all severed wires and cables. To carry the 4 t. weight it was necessary to brace the supports and support the board in a framework.

Screen work at the bottom was removed and 6 by 2 in. channel irons were made fast to each upright by 3/8-in. U clamps, which were later spot welded above the channel beams to prevent slipping.

As shown in Fig. 2, the movement was to be 9 ft. to the left, facing the board, and 18 ft. forward. It was planned to make the first move 9 ft. diagonally to the left, to get past the transformers shown in Fig. 2, then move straight forward.

Shoring was built up in front of the board of 8 by 8 in. risers with 8 by 2-in. cross braces, as indicated, to carry the weight which was taken on the 6 by 2-in. channel beams clamped to the uprights. For tracks, three 8-in. I beams 16 ft. long were laid and dollys fitted to the bottom of the shoring to run in them, position and spacing of the tracks being carefully measured so that no side strains would be induced as the board was moved.

Three chain hoists were used, at the center and at 6 ft. from each end. These were worked simultaneously so that the board would not be strained or cracked.

Lifting, mounting on dollys and making the 9-ft. diagonal move took 30 min. The load was then lowered onto six A frame horses, while shoring, I beams and dollys and chain hoists were shifted as necessary.

Movement forward was carried out same as the first move without mishap or delay.

While the board was on the horses, a wall was built 8 ft. behind and 1¼-in. iron pipe braces were built in to back brace the switchboard in its final position.

Sheet metal cable duct was extended, also conduit, after which all wires and cables were extended and connected by two electricians and a helper in less than a week.

In the final position, holes were drilled in the concrete floor and anchor bolts placed, back braces connected from the wall and the job was complete.

Turbines driven by exhaust gases have been successfully used for compressing air for supercharging Diesel engines.

Pump Requirements for Heavy Liquids

IN PUMPING thick or viscous liquids, the same considerations hold as for water except that extra friction must be considered, speed will be lower to get good valve action and capacity will, therefore, be less for a given pump. For liquids with viscosity 500 sec. Saybolt or higher, such as tars, cold oils, glucose, heavy syrups and molasses, reciprocating or rotary pumps are almost essential. For thinner oils and liquids of lower viscosity, centrifugal pumps are suitable but with the same restrictions as for water, that the reciprocating pump

PRACTICAL SUCTION LIFTS AND HEADS, FT.

	Temp. of Water, Deg. F.								
	60-80	100	120	140	160	162.5	165	180	200
Kind of Pump	Lift, Ft.						Head, Ft.		
Recip'g. & Rot'y..	22	17	12	6.5	1.5	1.0	0.0	3.5	9.0
Centrifugal	15	15	10	5.5	0.5	0.0	1.0	4.5	9.3

is better in the field of high head for quantities up to 300 g.p.m. and that reciprocating or rotary pumps will handle higher suction lifts than centrifugals.

Speeds Must Be Slow

When handling light liquids, reciprocating pumps should run at not over 100 r.p.m. and for heavier liquids at speed slow enough to permit closure of valves at the reversal of the stroke. The heavier the liquid, the slower the speed. This slowing down results in pulsation of flow in the line, hence a duplex or triplex pump is advantageous in producing even flow; also air chambers on suction and discharge will help to even the flow and to relieve shock on the driving mechanism.

To start the liquid column in motion requires a large force and this heavy starting torque must be considered when choosing a motor or other means of driving the pump. A compound-wound, direct-current motor or slip-ring induction motor with outside resistance in the rotor circuit are suitable types. A synchronous motor will require exceptionally high starting and pull-in torque to drive the pump satisfactorily.

Of course, a relief valve should be provided in the discharge pipe near the pump to take care of over pressure in case of stoppage of the discharge line or of starting the pump with all discharge valves closed.

Factors in determining on a pump installation are the total head to be overcome, amount of liquid to be handled and power required for driving.

Head Pressure and Friction

Head to be overcome is made up of the lift, friction head in suction and discharge piping and head to produce velocity at the outlet of the discharge pipe. In case liquid comes to the suction under a pressure head, this is negative lift and is to be subtracted from discharge lift. Also, if liquid has velocity at the entrance to the suction pipe, this should be subtracted from the discharge outlet velocity in figuring velocity head. That is, however, an unusual condition. Pressure due to lift will vary with specific gravity of the liquid and friction head in the piping with viscosity.

It is better to determine the total head in feet for the liquid to be handled, then consider the specific gravity in calculating the horsepower needed for driving the pump.

Putting the above as formulas:

$$h_t = h_l + h_f + h_v \quad (1)$$
$$h_l = h_d + h_s \quad (2)$$
$$h_f = C \times l \times v^2 \div (d \times 64.4) \quad (3)$$
$$h_v = (v^2_d - v^2_s) \div 64.4 \quad (4)$$

In these formulas, h is head in feet and v velocity in feet per second, the subscripts t, l, f, v, d and s denoting total head, lift, friction, velocity, discharge and suction. In (3) the value of v is that for the pipe being considered, based on volume of liquid handled and internal area of the pipe. C is a constant which varies with the size and condition of pipe, velocity of flow and viscosity of the liquid. Values for C are shown in the curves of Fig. 1; horizontal values are $v \times d \div k$ and vertical values are for C, three sets of horizontal values and curves being given for the sake of clearness when velocities and pipe diameters are small. It is to be noted that curves A and D are for ordinary iron pipe, 15 yr. in service, B and E for new smooth iron pipe, C and F for new smooth brass and steel pipe. G is for all kinds of pipe since, for values of $v \times d \div k$ below about 0.15 the influence of pipe size is greater than that of pipe surface condition. For formula (3) and the curves, v is velocity in feet per second, d is internal pipe diameter and l pipe length, both in inches; k is the viscosity of the liquid, as expressed in centipoises.

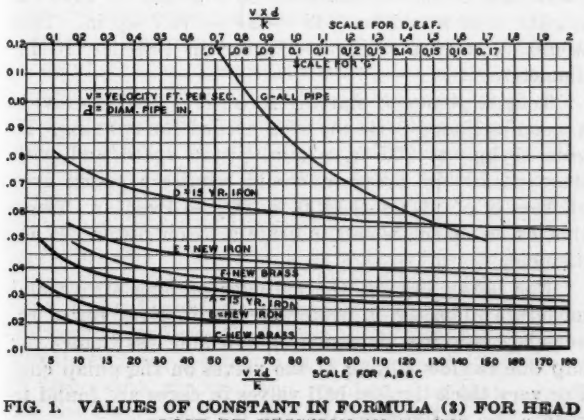

V x d / k
SCALE FOR D, E & F.
SCALE FOR G
V = VELOCITY FT. PER SEC.
d = DIAM. PIPE IN.
G-ALL PIPE
D = 15 YR. IRON
E = NEW IRON
F-NEW BRASS
A = 15 YR. IRON
B = NEW IRON
C-NEW BRASS
V x d / k
SCALE FOR A, B & C

FIG. 1. VALUES OF CONSTANT IN FORMULA (3) FOR HEAD LOST BY FRICTION IN PIPING

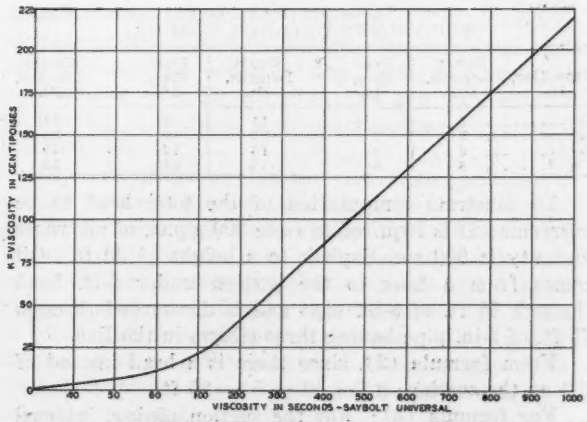


FIG. 2. RELATION OF VISCOSITY IN CENTIPOISES TO VISCOSITY IN SECONDS, SAYBOLT UNIVERSAL

Relation between values of viscosity in sec. Saybolt and of k is shown in Fig. 2. For water the value of k is 1 at 69 deg. and, for practical purposes, may be taken as 1 for all temperatures.

Viscosity Factor

The curves for k, its relation to viscosity in sec. Saybolt and the following table of values of k for various fluids at different temperatures, Table I, are

TABLE I. k = VISCOSITY IN CENTIPOISES FOR VARIOUS LIQUIDS

Liquid	Temperature, Deg. F. 40	60	70	100	120	150
Asphalt	...	6200	3250	650	300	...
Castor oil	4600	1270	860	286	154	77
Cod liver oil	...	77	61	32	22	...
Corn syrup (Karo)	...	...	3300	660	286	119
Corn syrup (heavy)	...	...	...	30,200	7600	1830
Crude oil (Bradford)	12.8	7.4	5.6	3	...	...
Crude oil (Crane Co.)	39	29	25.4	16	12.5	9
Crude oil (Mexican)	...	...	...	4400	1760	550
Crude oil (Yates)	58.5	32.5	25.4	12	9	4.5
Cylinder oil (600 W)	...	...	4400	660	310	116
Fuel oil (Bunker)	...	...	6600	1420	605	220
Fuel oil (Furnace)	...	7	6	3.8	3.5	...
Glucose	...	...	...	...	...	2400
Glycerine	19.2	11.5	9.2	5	...	...
Lard	...	...	...	52	32.5	...
Linseed oil	...	68	54.3	32.5	21.8	...
Machine oil	770	308	198	72.7	42.5	20.5
Medium auto oil	418	165	110	43.4	25.4	14.2
Medium auto oil (Royal)	660	275	176	68	39	...
Medium auto oil (Tide Water 114)	378	148	110	43.2	26.1	14
Molasses (heavy)	...	...	6600	1870	925	374
Orange syrup	4400	1760	1060	363	192	88
Printers ink	...	39,000	14,000	1940	670	390
Quenching oil	350	165	115	48	30	15.5
Water glass	...	4300	2820	975	530	270
Sugar solution	...	...	19.5	9.5	6.5	4.2
Sugar syrup	...	2200	...	264	...	48
Coke oven tar	...	...	770	137	61.5	...
Turbine oil (heavy)	550	264	180	75	46	24
Turbine oil (light)	202	101	72.5	34	21	12
Water	1	1	0.95	0.92	0.89	0.87

from a Handbook on Pumping issued by Goulds Pumps, Inc., of Seneca Falls, N. Y.

Effect of Fittings

Head due to pipe friction will be materially affected by fittings and valves; for each 90-deg. elbow the friction will be as great as for the equivalent length of straight pipe shown in Table II. Where a plugged tee is used in place of an elbow, if liquid enters the run of the tee, the friction head will be twice that for an elbow; if liquid enters at the branch opening, friction will be three times that for an elbow. Friction through a wide open gate valve can be neglected but for a globe valve the friction head will be equivalent to a pipe length of 200 times the pipe diameter. Evidently, globe valves should be avoided in piping for liquids.

TABLE II. PIPE LENGTHS HAVING FRICTION HEAD EQUIVALENT TO 90-DEG. ELBOWS

Pipe Size, In.	Equiv. Length, Ft.	Pipe Size, In.	Equiv. Length, Ft.	Pipe Size, In.	Equiv. Length, Ft.
¼	3	2½	11	8	24
½	5	3	15	10	30
¾–1	6	4	16	12	40
1¼–2	8	6	18	14	54

To illustrate computation of the total head to be overcome: It is required to raise 800 g.p.m. of oil whose viscosity is 500 sec. Saybolt to a height of 30 ft. Oil comes from a tank to the suction under 5-ft. head through 15 ft. of 8-in. pipe and is discharged through 75 ft. of 6-in. pipe having three elbows in the line.

From formula (2), since there is a head instead of lift on the suction; $h_1 = 30 - 5 = 25$ ft.

For formula (3): For the suction piping, internal area of 8-in. pipe is 50 sq. in. and diameter 7.98 in. 800 g.p.m. at 231 cu. in. per gal. is 184,400 cu. in. per min. or 3080 cu. in. per sec. Velocity will be $3080 \div 50 = 61.6$ in. or 5.13 ft. per sec. Length of pipe $= 15 \times 12 = 180$ in.

To get the value of C: Refer to Fig. 2 and for viscosity 500, the value of k is 109. Then $v \times d \div k = 5.13 \times 7.98 \div 109 = 0.375$. From curve F of Fig. 1, the corresponding value of C is 0.0413.

$h_f = 0.0413 \times 180 \times 5.13^2 \div (7.98 \times 64.4) = 0.4$ ft.

For the 6-in. discharge pipe, internal area is 28.9 sq. in., diameter 6.06 in.; velocity, $3080 \div (28.9 \times 12) = 8.9$ ft. per sec.; $v \times d \div k = 8.9 \times 6.06 \div 109 = 0.494$; C = 0.039; for L, the equivalent of three elbows is, from Table II, 54 ft. of pipe or a total length of $75 + 54 = 129$ ft. $= 1548$ in.

$h_f = 0.039 \times 1548 \times 8.9^2 \div (6.06 \times 64.4) = 12.27$ ft.

Total friction head is, then, $0.4 + 12.27 = 12.67$ ft.

Since entrance velocity at suction is zero and discharge velocity from the 6-in. pipe is 8.9 ft. per sec., $h_v = 8.9^2 \div 64.4 = 1.23$ ft.

Combining the values found,

$h_t = 25 + 12.67 + 1.23 = 38.9$ ft. head against which the pump must operate.

Power Required for Driving

Power required to move the liquid, of specific gravity s, will be

$$HP. = Ft.\ head \times g.p.m. \times s \div 3960$$

Oil above will have a value of s of 0.9 hence,

$$HP. = 38.9 \times 800 \times 0.9 \div 3960 = 7.06$$

For a pump of capacity to handle 800 g.p.m., efficiency will be 58 to 80 per cent. Assuming an average value of 70 per cent, the power needed to drive the pump will be $7.06 \div 0.70 = 10.1$ hp. Adding 10 per cent for friction and losses in driving mechanism gives 11 hp. to be provided for.

This amount of power should be sufficient for starting as well as running, since velocity will be low at starting but, as already mentioned, provision must be made to give high starting torque to overcome inertia of the long column of liquid.

Cylinder Size

As to size of pump required, a reciprocating pump at 100 strokes per minute must handle 8 gal. per stroke. For 200 ft. a min. plunger speed, the stroke would be a 24-in. and, as the volume must be $8 \times 231 = 1848$ cu. in., the area would be $1848 \div 24 = 76.7$ sq. in. This would require a cylinder 9⅞, or in practice 10 in. diameter.

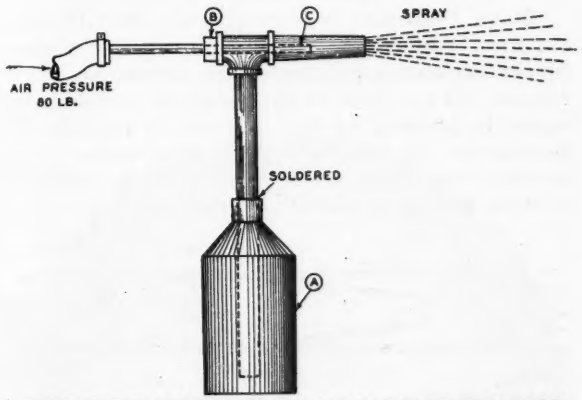
To give plenty of starting force, it is best to provide a steam cylinder twice the area needed for running. To give 11 hp., at 200 ft. a min. piston speed and with steam at 100 lb. pressure, would require a piston area of $A = 11 \times 33{,}000 \div (100 \times 200) = 18$ sq. in. Twice this, or 36 sq. in., would indicate a steam piston 6¾ in. diameter.

For heavy liquids, the cylinder of long stroke and moderate diameter is preferable, as it gives fewer reversals, hence less pulsation of flow and less chance for slip due to slow closing of the valves on the pump end. For very thick liquids, ball valves in cages are found to reduce slip and friction through the valves.

Ingenious Paint Sprayer

SOME TIME ago the writer saw a home made paint sprayer that did all that was expected of it. An electrician had rewound a 75-hp. induction motor in a rather sparsely equipped repair shop and made up this sprayer to apply more readily the paint to the coils. The sprayer enabled him to get the varnish between the coils where they entered the stator iron more thoroughly than could have been done with a brush. The insulating varnish was thinned out considerably more than for use with a brush.

Can A had a screw top into which the upright pipe was soldered, the pipe reaching nearly to the bottom of the can. B is a reducing bushing and C is a piece of ⅛-in. pipe with a long thread, so it could be screwed into the bushing far enough to end at a considerable distance beyond the upright pipe as shown at C. The



IMPROVISED SPRAYER USED TO PAINT MOTOR COILS

can had a capacity of one quart. This sprayer functioned perfectly and the rewound motor was thoroughly painted by the use of this sprayer.

Cold Spring, Minn. CHAS. A. PETERSON.

Steam Hammer Insulation

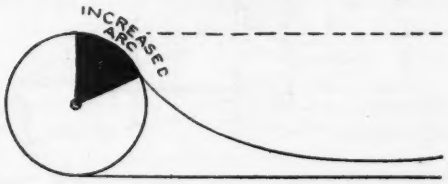
PIPE COVERING has a special significance in hammer shop operation. Oftentimes forge shop buildings are loosely closed in winter so that an uncovered steam pipe is exposed to ideal condition for rapid condensation of steam. Necessity for frequent repairs on hammer cylinders and the excessive vibrational shock during operation has, as a rule, discouraged covering either the hammer cylinder or the steam pipe adjacent to it. This, with the intermittent operation of the hammer, makes for accumulation of moisture, which is the arch enemy of lubrication. Under these conditions, lubrication and rod packing losses are excessive, also the cylinder oil which is carried on with the exhaust steam produces conditions in the heating system which are all but intolerable. If an electric generating plant is operated with the exhaust steam, every precaution must be taken to prevent this condensation, as well as the oil content of the steam from entering the turbine. The writer knows of one forge shop where this condition, combined with carry-over from the boiler was so bad that the exhaust lines from the hammers were carried outside of the forge shop windows and terminated at that point, with the result that the side of the building and surrounding objects were literally sprayed with oily whitewash.

These conditions are aggravated by failure to cover the steam lines. The Studebaker corporation has found that sponge-felted pipe covering reënforced with chicken wire and protected with a sheet metal casing will stand the shock and abuse incident to hammer operation satisfactorily. The same type of covering has been applied successfully to one hammer cylinder, and in all probability will be applied to others. This latter application, however, is expensive and the desirability of using it generally has yet to be demonstrated. Experiments are now being conducted on a 12,000-lb. hammer to ascertain the value of cylinder lagging under different conditions. A surface condenser has been especially installed on this hammer for the purpose of answering this question on the basis of facts.

So. Bend, Ind. C. C. WILCOX.

Slack Belt Practice

ONE OF THE most recent and convincing proofs of practicability of slack belts comes from Ohio State University. Experiments conducted by Professors C. A. Norman and G. M. Moffat were run with a leather belt on 6-in. steel and 6-in. cast-iron pulleys at 15 ft. centers. The belt traveled at the rate of only 895 ft. a min., yet pulled 104.8 lb. per inch of width with a slip of less than 2 per cent. The slack side sagged so that it almost touched the tight side, making it impossible to run the belt any slacker. The tension ratio was 30, which means that the tension in the tight side of the belt was 30 times



INCREASE OF BELT CONTACT BY RUNNING SLACK

that in the slack side. Or, in actual figures, the tension in the tight side was 104.8 lb. and in the slack side 3.49 lb. per inch of width.

Sketch herewith shows one important advantage of running belts slack. The black area shows the increased arc of contact that is obtained by running the belt slack. The dotted line shows where the belt would be if it were tight. In this instance, if tight, the arc of contact on each pulley would be only 180 deg. By running the belt slack as shown, the arc is 240 deg. Since pulling capacity increases with the arc of contact and the coefficient of friction, it becomes clear why slackness is possible and desirable.

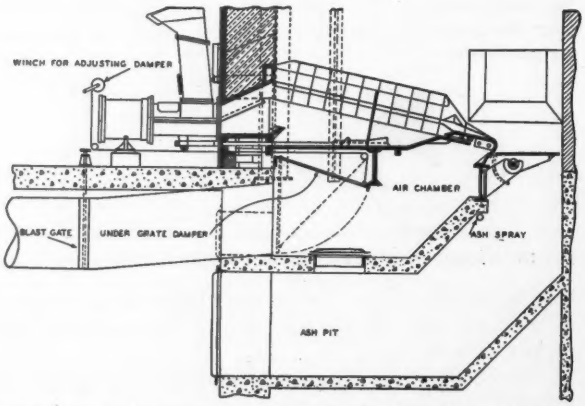
Chief requisites of slackness are: high coefficient of friction between the belt and the pulleys; good shaft and pulley alinement, and a steady load. If the load is variable, as is common with compressor drives or hammer drives, much slackness without the use of a wrapper pulley is inadvisable because flapping of the belt is sure to result. A wrapper pulley, however, will eliminate flapping and generally is a good thing on any drive. Slack belt drives and wrapper pulley drives are, after all, closely related.

Newark, N. J. W. F. SCHAPHORST.

Sectional Draft Control Increases Combustion Efficiency of Stoker

ABOUT 7 OR 8 YR. ago the writer had difficulties with underfeed stokers similar to those stated in the December issue and overcame them by splitting up the air supply as shown in illustration. The length of the stoker was divided into two separate parts, the front portion being provided with a damper which could be closed at will, partially or completely, depending upon the load carried by the boiler.

Our boilers are of 600 hp. and each stoker has seven retorts. The day load, at the time of our troubles, was



FURNACE EQUIPPED WITH SECTIONAL DRAFT CONTROL SHOWING DAMPER IN FRONT SECTION ALMOST CLOSED.

about 175 per cent rating and the night load, about 75 per cent. We had no trouble maintaining efficient combustion during the day time but at night the troubles you described were ours.

Closing off the air blast from the front part of the stoker and causing more air to be sent to the rear, as shown in the illustration, permitted us to burn the coal on the rear end of the stoker, more efficiently. Our coal averages 12,500 B.t.u. dry, with 31 per cent volatile and about 11 per cent ash.

We were much concerned, when we installed the dampers, whether we could produce smokeless combustion but we found no trouble at all in doing so. We were able to increase the quantity of CO_2 formed, 1½ per cent which resulted in a saving of coal amounting to from 1½ to 2 t. every night.

St. Louis, Mo. THOS. H. SMITH.

Excess Air in Refuse Wood Combustion

MANY ENGINEERS, in discussing the effect of excess air upon furnace conditions, claim that it destroys proper combustion and lowers the percentage of CO_2 formed. At our plant we have overcome trouble in this regard by breaking up the air stream by means of diffused steam. Air entering from a cyclone under a 11 oz. pressure was broken up successfully by the admission of steam through a specially designed jet.

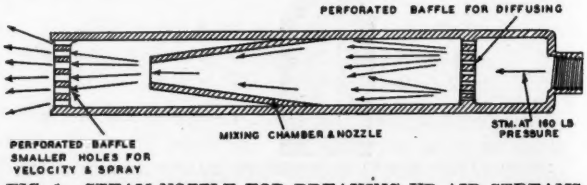

PERFORATED BAFFLE FOR DIFFUSING
PERFORATED BAFFLE SMALLER HOLES FOR VELOCITY & SPRAY
MIXING CHAMBER & NOZZLE
STM. AT 100 LB PRESSURE

FIG. 1. STEAM NOZZLE FOR BREAKING UP AIR STREAMS

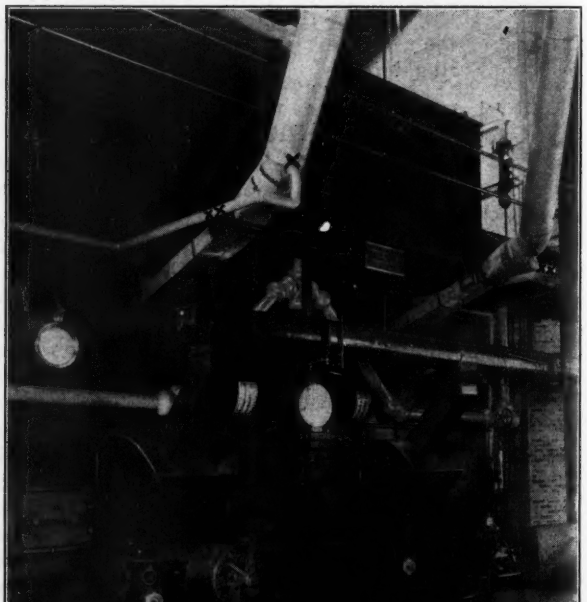


FIG. 2. STEAM COMING THROUGH PIPES XX MIXES WITH WOOD REFUSE FUEL AND AIR IN SPOUTS X

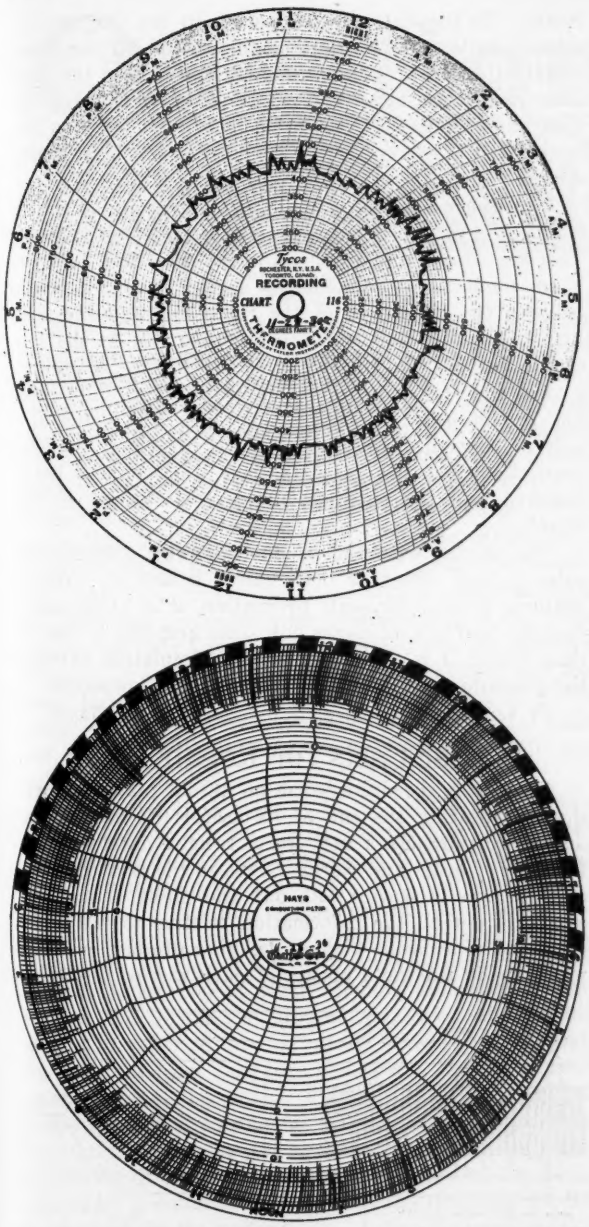


FIG. 3. TEMPERATURE AND CO_2 CHARTS TAKEN FROM 300-HP. WATER-TUBE BOILER OPERATING AT 175 PER CENT RATING WHEN FITTED WITH STEAM JET AIR STREAM DISPERSER. TEMPERATURE OF GASES TAKEN AT LAST PASS TO STACK

Refuse, such as small particles of sawdust and shavings, are spouted automatically into the furnaces from the cyclone into which they had been discharged by means of large fans from different parts of the plant. Consequently, considerable excess air, still is maintained in the final flow of the material going from the cyclone to the boiler furnaces although much of the excess air is removed in the cyclone. Since the amount of excess air cannot be reduced sufficiently before reaching the furnace, an over-draft pressure of 0.05 in. of water is set up, resulting in the formation of a relatively poor percentage of CO_2 and in an excessive increase in stack temperature.

By the application of the nozzle, Fig. 1, the excess air current is broken up just prior to entrance into the furnace, the steam coming through the pipes xx, Fig. 2, and entering the fuel feeder pipes coming from the cyclone at x. The nozzle action creates a partial vacuum and assists the fuel feeding process without destroying the over-fire draft or affecting the automatic damper regulation. The flow of refuse entering the boiler is under the complete control of the operator; when excess of refuse occurs the flow is directed to a storage bin.

Accompanying CO_2 and temperature charts show the condition of the gases after leaving the last pass of the boiler and just before entering the stack. The charts were taken when the boiler was operating at 175 per cent rating. Accomplishment of the good combustion indicated by the diagrams in refuse-wood burning furnaces such as those installed at our plant is possible, therefore, without excessive expenditure for equipment.

Milwaukee, Wisc. L. A. CORWIN.

Safe Boiler Operation Needs Automatic Stop and Check Valves

BURSTING of a tube in one of the three oil-fired boilers in a cold-storage and ice-making plant afforded a convincing example of the need of automatic stop-and-check valves in the main steam outlets. During the night run the tube let go. The two men on watch in the boiler house were close to the exits at the moment of the accident and so escaped injury and, as the pump for delivering the fuel oil to the burners was near one of the exits, there was no difficulty in extinguishing the fires. Nothing then remained but to wait outside while the water and steam were spouting from the crippled boiler. In about 5 min. the disturbance had subsided enough for the men to go about getting the plant back in service.

While the damaged boiler was exhausting its contents, the water in its two companions was being lowered through the main connections by the siphoning action produced. These boilers were refilled from the street main, the fires were started; steam was raised and the plant was again in operation, after a shutdown of about an hour and a quarter, but with the two good boilers carrying excessive overload. Aided by the fireman and his helper, the engineer then cut out the burst tube and replaced it with a sound one. In about 4 hr. the disabled boiler was repaired and again in service.

This emergency was handled skilfully and with good speed but the delay and trouble would have been considerably lessened had the outlet nozzles been fitted with automatic non-return valves. So equipped, the damaged boiler would have been cut off from the main line as soon as the tube let go and there would have been no break in the supply of steam from the others.

Automatic valves should be of the two-way type for it is just as important to provide a safeguard against possible breaks in the main steam lines and failures of large steam-consuming apparatus as it is to secure prompt isolation of a damaged boiler. Where a number of boilers are connected to the same main header, it is essential that each be provided with an ordinary stop valve in addition to the automatic valve. But the automatic valve should be attached directly to the outlet nozzle, so that it can be overhauled whenever the boiler is out of service.

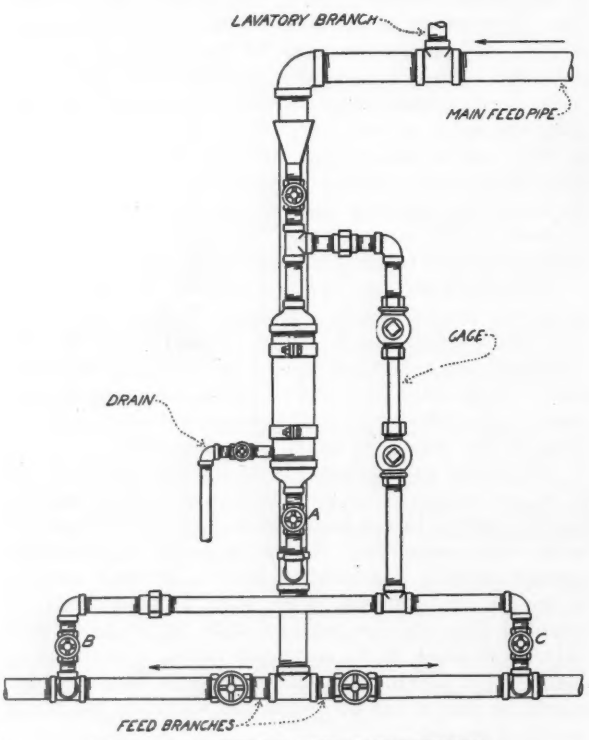
No automatic machine can be expected to give dependable service, if it is neglected. The automatic stop-and-check valve is no exception. Every time the boiler is cut out for cleaning or repairs, the automatic valve should also be given a thorough going over. Especial attention should be paid to any of its parts that are liable to become stuck because of excessive friction, such as those that move through packing glands. Graphite lubrication is best for these. In any case, precautions should be taken to avoid a gummy condition that would retard free movement of any part. If the fittings include weighted levers or springs, the adjustment of these should be tested, to make sure that there will be no dancing or pounding when the valve is in service.

Where the valve has an internal dashpot, a small hole should be drilled and tapped in the bonnet for attachment of an oil cup, using oil as nearly non-carbonizing as possible. The metal rings used for packing the pistons of these dashpots should be inspected closely, since they may become clogged by grit carried from the boiler by the steam current, or by the carbonized remains of the lubricant. The packing should fit loosely for, although a tightly adjusted piston might work freely when cold, it probably would not do so in service, with the high steam temperature tending to expand and lock the friction rings.

St. Louis, Mo. A. J. DIXON.

Graphite Feeder for Boiler Water

IN A SMALL manufacturing plant, hot water for lavatory purposes was supplied from the feedwater line in the boiler room, the feed pump discharging through a closed heater, so there was no chance of the wash water being contaminated by any trace of oil in the exhaust steam. To prevent scale formation in the two return-tubular boilers, it was decided to provide for the occasional injection of a quantity of graphite into the feed current. As graphite could not be delivered through the feed pump, it had to be sent in at a point between the boilers and the lavatory branch, the sketch herewith showing how this was accomplished.



GRAPHITE FEEDER AND CONNECTIONS

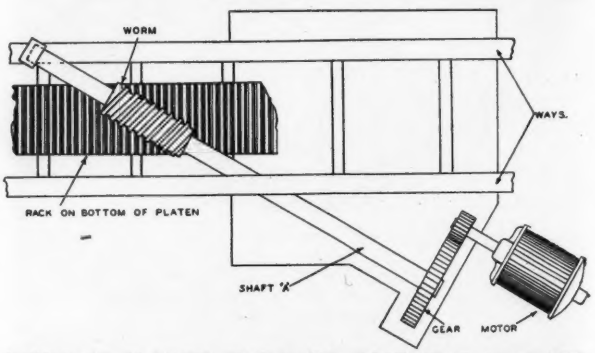
Receptacle for the graphite was made of an 18-in. length of 4-in. pipe, capped at each end with a reducer. This was strapped to a vertical in the main feed line. A ½-in. connection, controlled by a gate valve, was made between the lower end of the receptacle and the feed line. From the top end a ½-in. pipe ran to the two smaller branch feed lines running directly to the boilers, a glass gage for showing the quantity of graphite passing through being inserted in this pipe. The bodies of a pair of discarded water-gage valves provided the end connections for the graphite gage, the bonnets being removed and the openings plugged, as shown in the sketch.

The device was put in operation by opening the valve A and either or both valves B and C. Where graphite is used for scale prevention, it is unnecessary that the feed be continuous but, since graphite is heavier than water, it is essential that the circulation through the graphite tank be upward rather than downward.

St Louis, Mo. A. J. DIXON.

Plaster Casts for Repair Parts

RECENTLY, the drive worm on an old planer showed signs of nearing the end of its useful life and it was desired to purchase a new worm from a nearby manufacturer of gears and worms. Due to the fact that this machine was in service both day and night, it was necessary to get all the information relative to the worm pitch and dimensions without delaying production. This was done by making a plaster of paris cast of the worm.



MOULD OF PLASTER WAS MADE WITH GEAR IN PLACE IN THE PLANER

It will be noticed from the sketch that the shaft A enters the machine at an odd angle so that it would have been difficult to give the gear manufacturer full information in any other manner than that adopted. The plaster cast was a faithful replica of the worm shape and from it the manufacturer was able to quote us a price on a new worm.

This method should often be found useful around plants, as plaster of paris is available anywhere and any mechanic can quickly make plaster casts of odd shaped or unusual parts that can then be readily duplicated.

Cold Spring, Minn. CHAS. A. PETERSON.

Questions and Answers

Holly Steam Loop

How is the height of the condenser in a Holly steam loop system determined and what are the necessary connections for this system? R. B.

In the Holly loop system all condensate coming from pipe lines leading perhaps to many boilers, is collected in a common receiver, C, which is placed at the lowest point to be drained as shown in Fig. 1 and serves as storage for large or unusual quantities of water.

In this system the discharge chamber, which is a large cylindrical tank, is located at a considerable height above the water-line of the boiler and is connected with the feedwater heater through a reducing valve B. This system has been known to work well when the distance between the lower part of the discharge chamber and the water level was 19 ft. but usually a greater distance is preferred. A riser connects receiver, C, with this tank and a drop-leg leads from the tank to a point in the boiler below the lowest water level.

In starting up, a valve D, in the bottom of the drop-leg is opened to atmosphere to vent the pipe, until there is a continuous flow through this opening of steam and water entrainment from the receiver. The valve then is closed and, by bleeding the upper tank through the reducing valve B, into the feedwater heater, a pressure is maintained in the discharge chamber sufficiently below that of the receiver to permit of flow, the reduced pressure at the top of the pipe causing the water at the bottom to vaporize into wet steam which flows through the riser into the discharge chamber. The steam then separates from the entrained and condensed water and passes through the reducing valve into the heater while the water collects in the bottom of the discharge tank and in the drop-leg until the pressure head of the steam and water is sufficient to overcome the resistance of the check valve in the boiler.

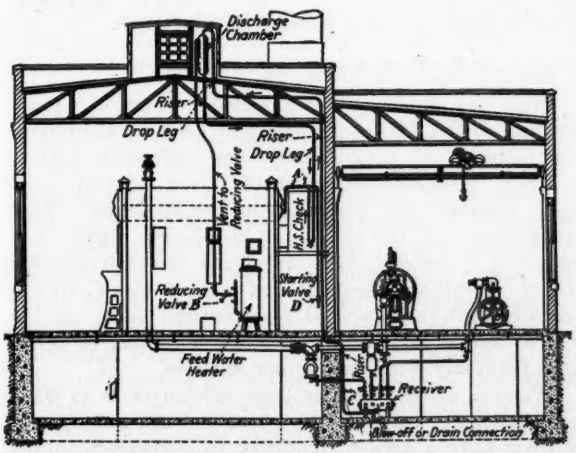


FIG. 1. GENERAL ARRANGEMENT OF THE HOLLY LOOP

Condensate from the various drips is forced, therefore, from the receiver into the riser in the form of a spray which is produced by a series of holes drilled in pipe A, Fig. 2. Connections to outlets E, lead to a blowoff or drain. In starting up, the difference in pressure between the riser and drop-leg, produced by the reducing valve B, causes the condensate in the riser to flow into the discharge chamber and raise the level of the water in the drop-leg to such a height that the added weight of water will overbalance the difference in pressure between the boiler and the discharge chamber and steam will flow through the riser in an effort to balance the pressure and entrained water will be carried along with it into the discharge chamber. Hence the process is automatic and continuous so long as the plant is in operation.

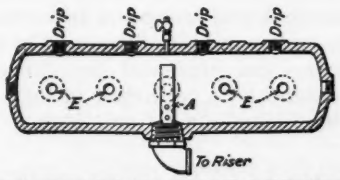


FIG. 2. CROSS-SECTION OF HOLLY RECEIVER SHOWING CONNECTIONS

Bearing Adjustment

How much should the main bearings of a Diesel engine be set up to allow for proper lubrication and quiet running? E. O. J.

A. Usually, the builder's book on operation and maintenance of his engines contains instruction regarding main bearings. If you do not have a copy of these instructions we would advise you to send to the maker for a copy.

Generally, the amount that should be taken up depends upon the alinement, kind of material, workmanship, and condition of the bearing and journal, the viscosity and wearing properties of the lubricating oil, the uniformity of supply and distribution of the lubricant, the surface speed and pressure and the kind and amount of foreign matter that is likely to find its way between the bearing surfaces.

Good procedure would be to gage the approximate thickness of shims required when the caps are set down hard on the journals by putting pieces of soft lead wire between the shim surfaces and compressing them in the process of drawing down the bearing bolts. Then try the setting of the caps with ample thickness of shims, gradually reducing this thickness until the bearings show a tendency to cut or heat when an extra shim may be added on each side of the bearing. Laminated shims, which are now in the market, serve this purpose well.

Editorial Comment

Development of Metals for the Power Plant

Safety and reliability are two qualifications demanded of every power plant and in many cases have barred the employment of practices which have theoretical possibilities of greatly advanced efficiency. Higher steam pressures and temperatures have been made possible during the past few years by advancements in metallurgy which have produced metals that will withstand the temperatures and pressures required by the engineers. Only a score of years ago superheated steam at a temperature considered low today was in disrepute because of the number of failures of the commonly used cast-iron valve bodies and pipe fittings. The use of steel for these services has eliminated this danger and encouraged metallurgists to go further in their search for and commercial development of high temperature metals.

While suitable metals for boilers, piping and prime movers using the modern high pressures and temperatures were available for some time before they were practically applied, the necessity of developing the auxiliary equipment delayed application for a considerable time. It is noteworthy that developments in power plant equipment during the past few years are largely the results of metallurgical discoveries and investigations rather than in mechanical movements and design arrangements, and it would appear that there is still room for considerable development along these lines.

Engineers are still waiting for a metal, comparable in price with iron and steel, that will resist corrosion for such uses as economizers, air preheaters, boiler breechings and chimneys. Other metals that will resist erosion would be welcomed for use in coal preparation and handling equipment. Embrittlement is another weakness encountered in some metals subject to vibration. Creeping or growing under subjection to high temperatures has given difficulty in stoker operation and in maintaining alinement of equipment run at high temperature.

All of these problems are being studied and progress is being made toward developing special metals for each application; engineers, however, could speed this development by carefully analyzing conditions surrounding a metal failure and, in the spirit of coöperation, reporting them to the manufacturer of the equipment as an aid toward improvement.

New Solutions for Old Problems

In scientific work of all kinds it is a common experience that the solution of a given problem may lead not only to new and previously unsuspected fields of investigation but also to new solutions of other problems that have been considered solved by other methods. This is especially true in applied science or engineering, whose practitioners work under the necessity of producing results in a given case that can be obtained at a profit to the owner of the equipment. A good illustration of this is the construction during the past few years of long pipe lines, some of them for transporting natural gas as far as 800 or 900 mi. That the ability to build the pipe line itself economically, safely and rapidly has made the present natural gas distribution system feasible cannot be doubted. In turn, it was the ability to fabricate this pipe in the field by welding that lowered the cost of erecting and maintaining it.

We thus have a new method of transporting gases and oils or other viscous fluids over great distances. What effect may this new method have on the generation and distribution of power?

It has already been suggested that high-voltage transmission lines might be supported on insulators in an oil-filled pipe, thus eliminating a great deal of expensive overhead construction. Of course, oil-filled underground cables for high voltages are now in use in this country and Europe and the principle itself is not new. But the entire proposal leads to some interesting speculations, especially if we also take into account the possibility of using the new types of vacuum-tubes rectifiers that may enable us to produce high-voltage direct current.

Besides this, the possibility of building long gas pipe lines leads to the idea of piping gas for boiler plant fuel from gasification or coal treatment plants at or near coal fields instead of hauling coal. Previous schemes for locating power plants at coal fields from which they would transmit electricity have usually failed to take into account the problem of condenser circulating water. The coal-processing plant, however, is not handicapped by lack of a large water supply, as its function would be to transmit not electricity but fuel, obtaining many valuable by-products in the process. As a matter of fact, this idea has been advocated by engineers of the highest standing and if we combine it with the suggestion for using long oil-filled conduits for carrying electric power, we have an interesting picture of the power plant industry that may develop in the future.

Welded Boiler Drums

From the standpoint of the boiler plant, the most significant news during the past year has been the public announcement by several large and influential manufacturers, of the development of fusion welding technique suitable for boiler drum construction. This strengthened by the action of the Navy, which, unhampered by boiler code requirements, has ordered both welded superheater headers and welded boiler drums, indicates that the proposed specifications being considered by the Boiler Code Committee will soon be acted upon favorably with only minor changes.

Welding experts are far from agreement as to what requirements or tests are important and discussions held by them have a decided tendency to degenerate into a

detailed discussion of controversal data that has little bearing on the main issue. Fortunately the members of the committee, who do not pretend to be welding experts, have seen fit to include all tests which may have a bearing on the matter, knowing that it is easier to safeguard construction now and reduce requirements later than it would be to boost the requirements after some disastrous failure. Some of the tests may be unnecessary but at least every satisfactory weld should be able to meet them even though their significance is nil.

Ample test data over a period of years show that any one of a number of responsible firms can weld pressure vessels so that the joint is as strong as, or stronger than, the plate. One firm in particular has long been a leader in the welded pressure vessel field and has an impressive record backed by years of successful application without a failure.

But, after all, is successful application of welding to pressure vessels in other industries comparable to their application in the boiler field? No more so than the unrestrained life of the early west is comparable to the restraints and conventions of more complicated life in the east. In a few years welding has literally carried the chemical and petroleum industries to an undreamed state of development. Boiler construction on the other hand has limped along for 150 yr. with riveting, which of recent years has been perfected to the point where an explosion is a rare occurrence in contrast with the almost daily failures of 30 yr. ago.

Although imperfect it has proved reliable in an industry which numbers pressure vessels in thousands where other industries number pressure vessels in units. Welding has carved a trail through the unknown and this trail has been traveled successfully by individuals. But is this justification for requesting the boiler industry with its army of followers to abandon a well traveled highway for a narrow, although well marked, trail?

It is not, although demands for drums thicker than can successfully be handled by riveting or forge welding together with the high cost of seamless drums and dangers of embrittlement, makes necessary some provision for allowing a few individuals in our industry to leave the beaten highway and travel a parallel trail.

Yet in their demands technical welders have ignored the human element. Having developed a welding technique, they know that their product is dependable and that the welder himself is a reliable judge of the weld. But how does the customer know this? With riveting there is something tangible to see and test, a poorly driven rivet or poor construction is visible. Hidden defects may be present but experience teaches the customers that the possibilities of their causing damage is remote. Yet welding must be accepted on faith. The customer is asked to risk damage to his property and the life of his employees on an unknown welder. The situation is analogous to that of modern physics. The modern scientist lives in a mathematical world impossible of visualization and until the masses reach the point where they think in terms of mathematical formulae instead of objects modern science is impossible of explanation except in a more or less abstract manner. The modern welder is enthroned on a pyramid of faith built up of experience which cannot be visualized but which can be festooned with successful applications in a familiar field until its outline can be distinguished.

Considering the psychological reaction of the public to something that they cannot visualize, it is difficult to explain the criticism of the non-destructive X-ray test. Welding experts generally (and rightly for them) consider this test unnecessary, contending that the place of the X-ray is in the development of welding technique. It is fortunate for the future of welding in our field, however, that at least one manufacturer has so ably supported this test and put it on a commercial basis. One man closely identified with the application of welding rather than its technical details said in support of this test "—how are we going to tell—men—that there is no defect in a drum——? With that thought alone in mind we have been interested in having some sort of non-destructive test—we would furnish a copy of that non-destructive test on that weld just the same as you furnish copies of heat reports on steel plates——." At the present time the X-ray test is the only answer to the question although other tests are in the course of development.

Insurance for Power Equipment

In spite of precaution, favorable supervision and inspection, and efficient workmen and operators, accidents do happen and the only satisfactory method yet devised for reducing the cost of such accidents is insurance. The advantage and usefulness of insurance in the case of steam boilers is seldom questioned and is almost universally accepted over a long period of years that it proves well worth the small cost.

The effect of the insurance is to divide the responsibility with the insurance company because it is to its advantage to inspect the equipment regularly and thoroughly so as to reduce accidents which they have to pay for. These inspectors being familiar with accidents which have occurred in the past in all parts of the country on all makes and types of equipment, know where to look for causes of failure, and are familiar with the methods of correcting them.

Some forms of insurance, such as boiler insurance and fly-wheel insurance are well known in the power field, but the fact that there is insurance applicable to all types of equipment is not known by a great many engineers. The following list taken from a single bulletin of one company lists a few of the items to which insurance is applicable:

Boilers, pressure vessels, steam pipes, air tanks, air pipes, digesters, economizers, electric steam generators, feedwater heaters, gas tanks, laundry machines, leather substitute machines, matrix tables, milk drying machines, dryers, molasses tanks, oil tanks, paper machines, blow-off tanks, rendering tanks and radiators, feed piping, blowoff pipes, silk finishing machines, portable boilers, refrigerating apparatus, rotary bleachers, kiers, stand pipes, steamboat boilers, track locomotives, superheaters, water tanks, vulcanizers, kettles, engines, air compressors, ammonia compressors, gas compressors, pumps, turbines, wheels, gear wheels, waterwheels, fans blowers, centrifugal dryers, line shafts, generators, motors, transformers, rotary converters, switchboards, oil switches, circuit breakers, switches, meters, reactors, rheostats, speed controllers, compensators and starters.

Power Plant Engineering Developments and News

New Recording Instrument

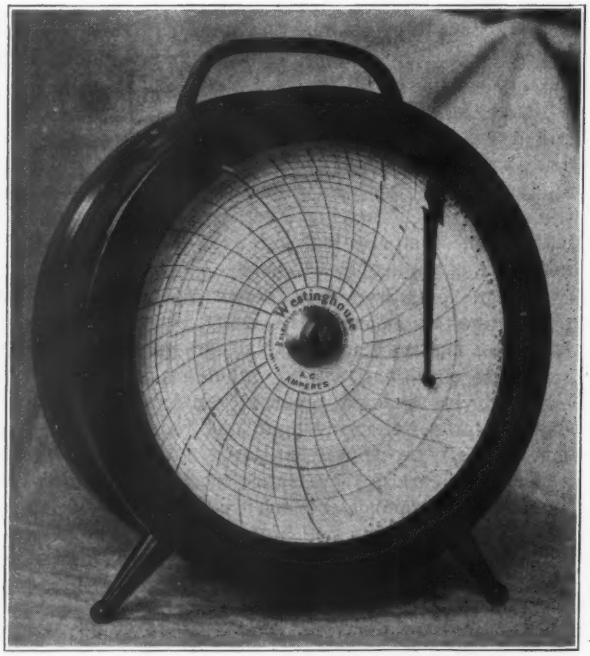
WESTINGHOUSE Electric and Mfg. Co. have recently announced a new circular chart recording instrument, identified as Type A. These instruments are light and small; they include ammeters and voltmeters and are made for switchboard mounting or as portable instruments.

They have numerous applications in industry. An example of their utility is their use for determining the most economical use of motor-driven machinery, the loading of motors, time of starting in mornings or after lunch hour, time of quitting, loss of time, and power required for different operations or depth of cuts.

While they are designed principally for alternating-current applications, they are also applicable to certain direct-current services. The ammeters are available in sizes ranging from 5 to 50 amp. and give a full-scale reading from zero to the value at which the meter is rated; the voltmeters are made in ratings varying from that which provides a scale of from 90 to 140 v. to that which records a maximum voltage of 550 v.

This instrument uses for the measuring unit a small motor structure, in which a laminated armature core or "rotor" is mounted in the field of an electromagnet. The air gap surfaces of the pole pieces are arranged to give as uniform a scale as is consistent with good performance at light loads. No delicate pivots or jewels are used for bearings. The control force is provided by heavy springs. The main shaft operates the pen directly and the mechanism as a whole is damped by means of an aluminum disk arranged to swing in the air gaps of a powerful set of permanent magnets.

Three kinds of clocks for moving the circular chart are provided; a key-wound, eight-day clock for driving the one-week charts; a key-wound, 36-hour clock for driving the one-day charts; and a sub-synchronous (self-starting) motor-driven clock, operated by the system frequency. Change gears are available to change synchronous-driven meters to other speeds.



TYPE A CIRCULAR CHART RECORDING VOLTMETER FOR PORTABLE USE

Ranarex CO_2 Indicator and Recorder

NEW MODEL of Ranarex CO_2 indicator and recorder has recently been placed on the market. The Ranarex principle, based on specific gravity, has been retained but the design has been simplified and the machine made more compact and rugged.

All working parts are designed to be easily accessible. The entire indicating and recording mechanism is attached to one plate and the driving mechanism, including the motor, to another. Both plates may be removed without the use of tools, by loosening a few wing screws; their removal opens all gas passages over their entire length. Connection between the humidifier compart-

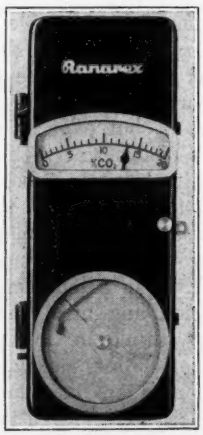


FIG. 1. RANAREX CO_2 INDICATOR AND RECORDER—WALL TYPE

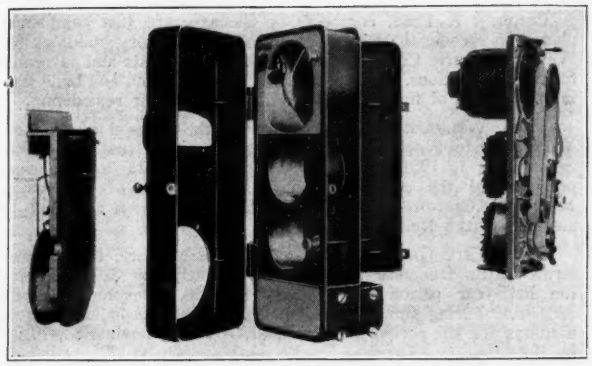


FIG. 2. RANAREX OPENED FOR INSPECTION. LEFT, PLATE WITH INDICATING AND RECORDING MECHANISM; CENTER, DUST-PROOF ALUMINUM CASING; RIGHT, PLATE WITH DRIVING MECHANISM

ments and the measuring chambers is established by channels of ample cross section.

In most instances, it is stated, the time lag will be less than a minute. This is of great importance to the power plant engineer and his assistants, as it enables them to correct firing conditions just as soon as a change is needed, hence the proper percentage of CO_2 can be maintained at all times.

Corrosion resistant materials such as bakelite and special alloy steels are used extensively for parts in contact with flue gas. The machine is enclosed in a dust-proof cast aluminum casing and is not affected by heat, moisture or shock. It is available for wall or panel mounting.

The standard 9-in. scale and circular chart 8 in. in diameter are graduated from 0 to 20 per cent CO_2, and accuracy within 0.3 per cent CO_2 is guaranteed. Scales from 0 to 30 per cent CO_2 for blast furnace gas and 0 to 40 per cent CO_2 for lime kilns are also available. The recording mechanism is driven interchangeably by a spring clock or an electric clock, as desired.

Ranarex Specific Gravity Recorders, with circular chart and of substantially the same construction as the CO_2 recorders described above, have been developed. The standard scale range extends from 0.2 to 1.0 (air = 1), but special ranges can be supplied upon request.

A special Ranarex recorder for the control of butane-air mixing has been developed. This machine has a specific gravity range from 1.0 to 1.2 with a superimposed adjustable scale graduated in B.t.u. per cu. ft.

The Permutit Co., 440 Fourth Ave., New York City, the manufacturer of Ranarex machines, is prepared to furnish them with any desired scale range for special applications where the specific gravity of a gas mixture is a guide to efficient and satisfactory operation.

Automatic Switchgear in Weather-proof Crucibles

GENERAL ELECTRIC CO. announces a design of weather-proof housing which has possibilities of application to various types of automatic switchgear. In the past the outdoor switch house has been confined in general to feeder equipment only. The new modification, while quite different in appearance, carries several of the desirable features characteristic of switch house construction and provides for the enclosure of power line switching equipment, etc.

Standard switch house doors front and rear, each provided for locking, afford access to both sides of the switchboard. Screened ventilators are placed in the sides and under the edge of the roof. These units are portable, being provided with lifting lugs on each side at the top. Leads for control wiring enter through the floor.

There are in addition, several features developed particularly for this type of service. The cubicle is heated by means of units attached to the sides. The temperature is regulated by means of a thermal relay mounted on the panel framework. A further refinement consists of an interior lining for the top, sides, floor, and doors of one-inch thick Celotex. A door switch at each end signals to the main operating headquarters when either door is opened.

These units are 7 ft., 6 in. high, 9 ft. long, and 6 ft. wide. They are shipped completely assembled for installation.

J-M No. 350 Semi-Metallic Packing

FOR SOME TIME PAST, according to the manufacturer, a number of engineers in a wide variety of industries have been testing a new packing, known as J-M No. 350 Semi-Metallic. This packing is plaited up square from

COIL OF J-M NO. 350 SEMI-METALLIC PACKING

a combination of asbestos fiber and non-abrasive metal, the whole is thoroughly lubricated and graphited.

Results so far have been decidedly satisfactory, it is stated by the Johns-Manville Corp., New York City, which feels that, in placing this new product on the packing market, it is offering the solution to many a vexing packing problem.

J-M No. 350 Semi-Metallic is designed for use against steam, air, water, oil, on centrifugal rods at high or low pressures and at temperatures up to 500 deg. F. It is also designed to be used in reciprocating rods and plungers, either alone or in combination with other rod packings.

The new packing is available in coil and ring form in sizes ¼ in. and up. A modified packing, No. 351 Semi-Metallic, is designed for use against gasoline and other cold mineral oils.

OVERHEATING in mild weather is a common fault of most heating installations, since systems are designed with capacity for the coldest weather. Since in the central states, hours of zero or below weather are some one per cent of the heating season, manual control results in overheating, wasteful of fuel and injurious to health. Automatic thermostat control is, therefore, a good investment.

News Notes

THE DEPARTMENT OF LABOR AND INDUSTRY, Commonwealth of Pennsylvania, extends to all friends of the Department a cordial invitation to attend the Pennsylvania Safety Conference which will be held in the Penn-Harris Hotel, Harrisburg, Pa., February 19 and 20. The Conference will open at 10:00 a. m. February 19 with an afternoon session at 2:00 p. m. followed by the dinner meeting at 6:30 p. m. The second day's session will begin at 10:00 a. m. February 20.

GREAT INTEREST in the eighth annual oil burner show to be held at Philadelphia next April is being displayed by manufacturers of oil burning equipment and accessories, according to the American Oil Burner Association, 342 Madison Ave., New York. Shortly after December 1 it is stated, only 19 booths out of 123 remained unsold and many of the remaining booths had been placed on option. The 104 spaces already sold have been taken by 63 exhibitors. Harry F. Tapp is executive secretary of the Association which is staging the show in connection with the annual convention at the same time.

T. K. QUINN of Cleveland and Charles E. Wilson of Bridgeport have been elected vice-presidents of the General Electric Co., H. H. Barnes, Jr., of New York has been made a commercial vice president in charge of the New York district and J. L. Buchanan of Bridgeport has been named president of the General Electric Supply Corp., according to an announcement by Gerard Swope, president of the General Electric Co., following a meeting of the board of directors of the company. At the same time the retirements of Vice-President Charles E. Patterson, who has been in charge of the merchandise department of the company and of Cummings C. Chesney, who has been one of the two vice-presidents in charge of manufacturing, were announced.

P. B. Zimmerman of Cleveland, sales manager of the refrigeration department, has been named manager, succeeding Mr. Quinn and J. W. Kewley of Cleveland, acting manager of the incandescent lamp department, has been named manager of the department. T. W. Frech, who was given a year's leave of absence as manager of the lamp department to head the RCA Radiotron Co. at Harrison, N. J., has been given an additional year's leave.

Mr. Quinn, who has been manager of the refrigeration department since its formation in 1927, will henceforth have headquarters at 120 Broadway, New York. He will retain general charge of the department and will also be chairman of a newly constituted G. E. Appliance sales committee. Other members of this committee will be: J. E. Kewley, C. E. Wilson, P. B. Zimmerman and G. A. Hughes of the Edison General Electric Appliance Co.

ONE HUNDRED PER CENT increase of plant capacity is expected to result from the expansion program started January 2 at the plant of The Libby Glass Co. at Ash St. and W. & L. E. R. R., Toledo, O. Equipment layout and the design for the buildings has been prepared by The H. K. Ferguson Co., Cleveland, O. This work was in charge of C. H. Van Tine, formerly president of The Devore Engineering Co. of Toledo now merged with the Cleveland firm. The contract for the construction has also been awarded to the Ferguson organization with orders to proceed at once with the initial phase of the program. The present work will include buildings required to house three new blowing machines, three furnaces, lehrs and other equipment necessary for an output of 40,000,000 tumblers per year. Modern mechanical equipment for handling both incoming materials and the finished product is to be installed. In addition to the manufacturing buildings there will be a new warehouse, engine room, machine shop, boiler house, producer house and batch mixer building. The total area of new floor space will be approximately 100,000 sq. ft., costing with equipment about $600,000. Production is scheduled to start in the new plant March 15. In general, the buildings will be of conventional type with structural steel frame, brick walls, steel sash, composition or corrugated asbestos roofing and concrete or wood block flooring. All power equipment is to be designed and installed by Ferguson Engineers. A battery of silos for the storage of materials is to be built in connection with the mixing equipment. When completed the Libby plant is expected to be one of the most modern and efficient units in the industry. Two hundred fifty tons of structural steel will be required.

AEROIL BURNER CO., Inc., West New York, N. J., announces the appointment of Herbert M. Orschel as field sales manager.

BATTELLE MEMORIAL INSTITUTE, Columbus, Ohio, announces the establishment at the Institute of a research project sponsored by The Ironsides Co. of Columbus, Ohio. This project will consist of a fundamental study of lubrication in respect to metal drawing and its proper application to modern practices. Dr. Robert C. Williams, a specialist in colloidal chemistry, joined the Institute staff on January 1, 1931. He will be in charge of this program of research work under the direction of Dr. H. W. Russell, chief physicist of the Institute.

CONDRON & POST, engineers of Chicago, are just completing plans and specifications for a group of large factory buildings for Western Electric Co. In view of present low costs and favorable financing conditions, they are advising clients to plan and build now in anticipation of future needs for new buildings or remodeling.

C. H. WHEELER MFG. CO. announces the removal of its New York office to Woolworth Bldg., 233 Broadway, New York City. Since Jan. 1, 1931, Thos. B. Whitted, assistant to the vice-president of the company, has been in charge of this office. Morris B. Carroll has also joined the organization and will be attached to the New York office.

SIOUX CITY GAS AND ELECTRIC CO., Sioux City, Iowa, under terms of its franchise tax, paid the municipality $29,534.51 for the half-year period ending Dec. 1, 1930, as compared with $28,387.82 during similar period in 1929. The tax indicates gross earnings for the period just ended $1,476,700 as against $1,419,800 in 1929.

LEWIS B. FISCHER, Chicago, vice-president of the Illinois Light and Power Corp. and the North American Power and Light Corp., has been elected a director of the Williams Oil-O-Matic Corp., Bloomington, Ill.

R. J. RUTHERFORD, for the past 22 mo. vice-president and manager of the Union Gas & Electric Co., Bloomington, Ill., subsidiary of the Associated Gas & Electric Co., has been transferred to Massachusetts as superintendent of seven major utilities operated in that state by the Associated Gas & Electric Co.

CONSOLIDATED ASHCROFT HANCOCK CO., INC., reports that for the year 1930 the operations of the company showed satisfactory net earnings. Despite the fact that these earnings were smaller than those of preceding years, they deserve a favorable comment based on the recognition of more strenuous business conditions prevailing throughout the past year. As its products are used by a wide variety of industries, the showing of the company for 1930 reflects the general decline of business during that period. Consolidated Ashcroft Hancock Co., Inc. is a subsidiary of Manning, Maxwell & Moore, Inc., New York City, and the latter is the sole owner of its capital stock.

THE CROLL-REYNOLDS ENGINEERING CO., INC. announces expansion of its sales and service facilities. Within the past three months arrangements have been made with the following organizations to handle Croll-Reynolds products: Starkweather & Broadhurst, Inc., Boston, Mass.; E. H. Bollenbacher, Atlanta, Ga.; Garrett-Burgess, Inc., Detroit, Mich.; The Smiley Equipment Co., Kansas City, Mo. The executive and engineering office staff at 17 John St., New York City, has been enlarged by the appointment of D. H. Jackson as sales manager. Mr. Jackson's past connections include approximately 6 yr. with Elliott Co. and 4 yr. with the American Chemical Society.

AT THE Chicago Power Show, Allis-Chalmers Mfg. Co., in booths 104, 5 and 6, will demonstrate its Armorclad switchgear with live parts enclosed, explosion-proof and fan-cooled motors, Texrope drives, transformers, two-stage centrifugal condensate pump with first stage in the center and two impellers outside for the second stage and pump units for boiler feeding and general service.

Whiting Corporation's exhibit at the Chicago Power Show, in booths 92, 3 will demonstrate a motor-operated stoker. Also in spaces 438-441 will be shown a stoker actually in operation, firing a boiler.

ILLINOIS TESTING LABORATORIES, INC., of 141 W. Austin Ave., Chicago, Ill., announces, through its sales manager, M. D. Pugh, the appointment of James H. Knapp Co., 4920 Loma Vista Ave., Los Angeles, with a branch in San Francisco, as its exclusive Pacific Coast distributor of its products for industrial purposes.

MELVILLE MEDAL of the American Society of Mechanical Engineers, established in 1914 by the bequest of Rear-Admiral George W. Melville, honorary member and past president of the Society, for an original paper or thesis of exceptional merit, was presented jointly to Professor Herman Diederichs of Ithaca, N. Y., and William D. Pomeroy, Seneca Falls, N. Y., as co-authors of the paper on The Occurrence and Elimination of Surges or Oscillating Pressures in Discharge Lines from Reciprocating Pumps. Professor Diederichs is Professor of Experimental Engineering and Director of the Sibley School of Mechanical Engineering, Cornell University. Mr. Pomeroy, who is considered an authority on oil pipe lines and pipe line pumps, is vice-president and general manager of Goulds Pumps, Inc., Seneca Falls, N. Y.

MERIAM CO., 1955 W. 112th St., Cleveland, O., has now completed a 50 per cent extension to its plant.

KENNEDY VALVE MFG. CO. announces the appointment of Harvey Embry as its representative in Detroit and the lower Michigan Peninsula, to handle Kennedy products.

CHICAGO PUMP Co., Chicago, Ill., announces that R. K. Rothrock, 2204 Jefferson Ave., New Orleans, La., will represent it in the New Orleans territory. J. M. MacCrea, 153 Oakland St., Syracuse, N. Y., will represent the company in the Syracuse territory.

FAIRBANKS, MORSE & Co. announces the appointment of C. B. Murphy as manager of the stationary Diesel engine sales with headquarters in Chicago. Mr. Murphy's experience, after he finished his schooling at Purdue University in 1911, has been almost entirely with the Fairbanks-Morse organization. For the first two years of his business career he was connected with the Engineering Department of the Illinois Central Railroad. In 1913 he became a general line salesman in the Florida west coast territory and since the introduction of the F-M Diesel in 1915 he has devoted his time to that one product exclusively with two years' time out in '18 and '19 for service in the Naval Aviation Ground School at Minneapolis. In 1924 he was transferred to the executive offices as assistant to the manager of the Diesel Engine Division and in 1929 was transferred to Washington as special representative of that division.

ON DECEMBER 31, R. R. Wason was elected president of Manning, Maxwell & Moore, Inc. He succeeded C. A. Moore, who had been the president of this company since April, 1927. Mr. Moore retains his contact with the company as chairman of the board of directors. Mr. Wason was also elected president of the Consolidated Ashcroft Hancock Co., Inc., one of the large subsidiaries of Manning, Maxwell & Moore, Inc. Mr. Wason's entire experience has had to do with merchandising and management problems. He was for many years director of merchandising of Proctor & Collier Co. in Cincinnati, where he worked on the problems of many large middle western manufacturers. Early in 1929 he came east to represent banking interests in the Clark Lighter Co. Mr. Wason will make his headquarters in the main office of Manning, Maxwell & Moore, Inc., in New York.

SARCO Co., INC., New York, announces the opening of new Canadian headquarters as follows: Sarco Canada, Ltd., Federal Bldg., 85 Richmond St., West, Toronto, Ont. The Canadian company will operate under the direct supervision of E. E. Wells, vice-president. H. T. Carter has been appointed general manager. Arrangements have been made with Mueller, Ltd., Sarnia, Ont., to manufacture the company's products in Canada. In Quebec and the maritime provinces, Peacock Bros., Ltd., of 660 St. Catherine St., West, Montreal, will continue to handle the sale of Sarco industrial products and all heating specialties will be in the hands of the Engineering Equipment Co., 1072 Beaver Hall Hill, Montreal. Gordon Russell Co., 744 Hastings St., Vancouver, B. C., has been appointed sub-agents for British Columbia.

MANUFACTURING OPERATIONS of the Industrial Brownhoist Corp., Cleveland, O., will be consolidated in the Bay City, Mich. plant of the company, according to an announcement by Alexander C. Brown, president of the company. Under ordinary conditions, the company employs about 500 men in its Cleveland plant. Decision to move the manufacturing division of the company to Bay City came after more than a year's consideration of the subject, according to Mr. Brown. "Careful study shows that substantial economies would result from enlargement and adaptation of one plant to house all manufacturing operations," he said. From six to eight months will probably be required for the transfer before shutting down the Cleveland plant.

Books and Catalogs

PULVERIZED FUEL BIBLIOGRAPHY, by Oscar Knabner. Published by VDI-Verlag, G.M.B.H., Berlin, NW 7, Germany, as the 23rd serial report of the Pulverized Fuel Committee of the German Coal Council. 116 p., 8 by 10 in., paper; price, 6 marks (about $1.25).

Probably the most complete bibliography of pulverized fuel firing ever prepared, this work contains more than 3000 reviews and almost 5000 reference sources. Over 400 publications of various sorts were referred to and about a third of these are American. The review in each case is printed in the language of the periodical from which it was taken, making in effect a combination of complete bibliographies in several languages, making it an indispensable addition to the library of individuals or organizations interested in pulverized fuel.

It is the result of 5 yr. work and was formed from a combination of two card index systems, one made for the private use of the author and the other from the bureau of the German Coal Council. The low cost of publication has been brought about by a subsidy granted by a number of societies and firms enumerated in the preface.

IN A RECENT 12-page bulletin entitled Make Walkways Safe, the American Abrasive Metals Co., 50 Church St., New York City, describes its various products for use on walkways and stairways. These include Feralun, Bronzalun, Alumalun, Nicalun. Detailed drawings show how this material is applied and perspective sketches help the reader to visualize the appearance of the completed job.

CORROSION AND HEAT RESISTANT NICKEL-COPPER-CHROMIUM CAST IRON is described in a paper by J. S. Vanick and P. D. Merica, presented in September before the American Society for Steel Treating. It discusses the characteristic of this metal and is being distributed in pamphlet form by International Nickel Co., 67 Wall Street, New York.

HOT LIME-SODA-PHOSPHATE TREATMENT of feedwater for high pressure boilers, by C. E. Joos, chemical engineer, is being issued in bulletin form by Cochrane Corp., Philadelphia, Pa. This discusses the difficulties that sometimes arise from feedwater in operating boilers at high pressures and temperatures and stresses the methods of eliminating these difficulties by suitable treatment of the feedwater. Charts, diagrams and photographs illustrate the text.

IN ITS RECENT CATALOG No. 30, Furnace Economy Co., 407 S. Dearborn St., Chicago, Illinois, describes its Economy air-cooled walls, gives data on the types of refractory blocks used, the method of supporting them in various types of boiler construction, together with blueprints and photographs showing actual installation.

METER DEVICES, relay test switches and accessories are described in catalog No. 100, a 36-page loose-leaf bulletin just issued by Meter Devices Co., Canton, Ohio.

CHEMICAL AND MECHANICAL UTILIZATION OF ACTIVATED carbon in water purification, are discussed in a recent bulletin, No. 6003, published by International Filter Co., 59 East Van Buren St., Chicago, Ill. This bulletin deals with hydrodarco, a special brand of water purification carbon sold by the company and describes its use in removing organic tastes and odors, free chlorine, organic coloring matter, and in the separation and removal of iron from water supply. Underlying principles to be followed for proper design and operation of equipment are discussed and data are presented from various installations. Costs of treatment are discussed in some length.

MIGHTY DROPS OF LUBRICANT is the title of a recent 30-page illustrated bulletin issued by Shaffer Oil and Refining Co., 300 West Adams Street, Chicago, Illinois. This discusses principles of correct lubrication, methods of lubricating steam turbines, steam engines, hydraulic equipment, compressors, and so on, and gives angineering detail on the composition of bearing metals, lubricating oils and data on clearances, friction and similar subjects.

HAYS COMBUSTION RECORDERS for CO_2, furnace draft and flue gas temperature are described in a recent 24-page, well-illustrated catalog, RA-31. Discussion is given of principles of combustion, operation of recorder, details of construction, method of installation and details of panel boards. This bulletin is distributed by The Hays Corp., Michigan City, Ind.

BROWN Electric Indicating and Recording Tachometers are described in a 16-page illustrated bulletin No. 46. Construction and operation of the instruments are discussed in detail and applications are shown. This is a recent publication of The Brown Instrument Co., Philadelphia, Pa.

IN GENERAL CATALOG 30, a loose leaf book of over 200 pages, in 12 sections, with many colored illustrations and blue prints, The McAlear Mfg. Co., 1901 South Western Ave., Chicago, Ill., discusses pressure and level control problems. Various sections discuss pressure, back pressure and vacuum regulators, pump governors, liquid level controllers, traps, water pressure regulators and the like, each section dealing with a specific group of controls. Data are given on pressures, temperatures and measurements, accompanied by installation drawings, roughing-in dimensions, tables and engineering data.

VITRIFIED glazed tile ash storage tanks, their design, construction, sizes and capacities and installation are discussed in a recent 16-page illustrated bulletin by United Conveyor Corp., Old Colony Bldg., Chicago, Ill.

COMBUSTION SYSTEMS, boiler settings, furnace linings and special refractories are illustrated and described in a new bulletin by Essex Engineering Co., Inc., Belleville, N. J.

FOLLOWING new bulletins have just been issued by General Electric Co., Schenectady, N. Y.: explosion chambers for oil circuit breakers, Bulletin No. GEA-372A; oil-filled coupling capacitors for carrier-current applications, GEA-1261; textolite molded control pulleys for aircraft, GEA-1254; hand starting compensators for squirrel-cage induction motors, GEA-140A; magnetic switch, across-the-line starter for induction motors, GEA-841A; automatic full-voltage controllers for synchronous motors, GEA-579B; totally enclosed fan-cooled induction motors, GEA-1326; hesitating control relays for direct current circuits, GEA-727B; automatic switchgear, GEA-1193A; indoor bus supports, GEA-721; oil circuit breakers, 7500 and 1500 v., 400 to 3000 amp., GEA-959B.

Power Plant Construction News

Ark., Blytheville—The Arkansas-Missouri Power Co., Blytheville, is reported planning a hydroelectric power project on the Spring River, Fulton County, entire project to cost over $250,000, including transmission system.

Calif., Stockton—The Schmidt Lithograph Co., Second and Bryant Streets, San Francisco, Calif., plans installation of electric power equipment in proposed new fiberboard mill at Stockton, where a tract of land has been acquired, entire project to cost over $150,000.

Colo., Colorado Springs—The Colorado Natural Gas Co., Independence Building, Arthur K. Lee, head, plans construction of a number of compressor plants in connection with a new pipe line for natural gas supply from Canon City to Colorado Springs, entire project to cost more than $2,500,000.

Colo., Pueblo—The Southern Colorado Power Co., Pueblo, is planning extensions and improvements in transmission lines and distributing system during 1931, to cost $275,000, including Pueblo, La Junta, Rocky Ford, Fowler and vicinity.

D. C., Washington—The Secretary of the Interior, Washington, will receive bids until Mar. 3, for one turbo-generator set and exciter, with all necessary pumps, condensers, valves, etc., including one open-type feed water heater, and one zeolite water softener, as per specifications on file.

Fla., Tampa—The Southwest Food & Refrigeration Co., Tampa, is said to have plans under way for a one-story cold storage and ice-manufacturing plant to cost over $75,000, with equipment.

Idaho, Idaho Falls—The City Council is said to have plans maturing for proposed hydroelectric power project on the Snake River, including construction of two power dams and two power stations, with capacity of 19,000 hp., entire development to cost over $2,500,000. Application for permission has been made.

Ill., Aurora—Miller, Bryant, Pierce & Co., 223 South River Street, plan installation of electric power equipment in proposed three-story addition to carbon paper and typewriter supply factory, entire project reported to cost about $80,000.

Ind., Indiana Harbor—The Inland Steel Co., Chicago, Ill. plans installation of electric power equipment in proposed new continuous sheet, plate and strip mill at plant at Indiana Harbor, Ind., entire project reported to cost over $1,000,000.

Iowa, Council Bluffs—The Citizens Power & Light Co., Council Bluffs, is planning extensions in transmission lines in Mills County, including substation facilities.

Kan., Kansas City—The Board of Public Utilities, Kansas City, has asked bids on general contract for a one and two-story addition to power plant, 95x125 ft., estimated to cost close to $100,000, with equipment. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is engineer.

Kan., Neodesha—The City Council is said to be planning early call for bids for extensions and improvements in municipal waterworks to cost about $65,000, to include a filtration and water softening plant.

La., Monroe—William A. Sailer, 3801 Mockbird Street, Dallas, Texas, is at the head of a project to construct and operate an ice-manufacturing plant on Layton Avenue, Monroe, reported to cost close to $100,000.

Md., Baltimore—The Harry C. Weiskittel Co., Inc., 4500 East Lombard Street, plans installation of electric power equipment in proposed new gas range and plumbing equipment manufacturing plant on Philadelphia Road, where a 24-acre tract of land has been secured, entire project to cost close to $100,000.

Mass., Worcester—The Standard Oil Co. of New York, 26 Broadway, New York, plans installation of pumping machinery and other power equipment in connection with a pipe line for oil transmission from East Providence, R. I., to Worcester, Springfield and vicinity, about 100 miles, entire project to cost over $500,000.

Mich., Marquette—The Duluth, South Shore & Atlantic Railway Co., Duluth, Minn., plans installation of electric power equipment in connection with a new ore dock at Marquette, with conveying, hoisting and other mechanical equipment, entire project to cost over $1,500,000.

Mich., Saginaw—The Valley Chemical Co., Saginaw, is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss estimated at $45,000.

Minn., Minneapolis—The Fairfax-Parsons Packing Co., 418 Third Avenue, North, is said to be planning installation of electric power equipment in connection with proposed rebuilding of meat packing plant, recently destroyed by fire with loss reported at $50,000.

Mo., St. Louis—The Crystal Ice Co., Omaha, Neb., has acquired property at Easton and Spring Avenues, St. Louis, and plans early construction of a two-story ice-manufacturing plant, 60x105 ft., reported to cost over $90,000, with machinery.

N. J., Atlantic City—The Pennsylvania Railroad Co., Broad Street Station, Philadelphia, Pa., plans installation of a steam power plant for heating and other service in proposed new union terminal on Arctic Avenue, Atlantic City, entire project to cost about $6,000,000. Company engineering department is in charge.

N. J., Elizabeth—The Fulton Specialty Co., 128 Fulton Street, plans installation of electric power equipment in connection with proposed rebuilding of four-story rubber goods manufacturing plant recently destroyed by fire with loss reported in excess of $125,000.

N. Y., Olean—The England Walton Co., Inc., Third and Vine Streets, Philadelphia, Pa., plans installation of electric power equipment in connection with proposed rebuilding of leather tannery at Olean, recently destroyed by fire with loss reported over $500,000.

N. C., Wilmington—The Delgado Mills, Wilmington, recently reorganized as the Spofford Mills, Inc., plan electrification of local cotton mill, in connection with an expansion and improvement program, reported to cost over $100,000. Company is operated by the Seaboard Public Service Co., 72 West Adams Street, Chicago, Ill.

Ohio, East Liverpool—The Peach Porcelain Co., West Sixth Street, plans installation of electric power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss reported at close to $75,000.

Okla, Chickasha—The City Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in municipal waterworks, for which a bond issue of $193,000, has been authorized.

Pa., Baden—The Pennsylvania Railroad, Union Terminal, Pittsburgh, plans installation of electric power equipment in proposed new river-rail coal terminal and distributing plant at Baden, entire project to cost $350,000. Company engineering department is in charge.

Pa., Corry—The McInnes Steel Co., Inc., Corry, Pa., plans installation of electric power equipment in connection with an expansion and betterment program to cost about $50,000.

Texas, El Paso—The Western Gas Co., a subsidiary of the El Paso Natural Gas Co., plans construction of four compressor plants, in connection with a proposed new pipe line from El Paso to Douglas and Bisbee, Ariz., entire project to cost $6,000,000. The Stone & Webster Engineering Corporation, 49 Federal Street, Boston, Mass., is engineer in charge of the project.

Texas, Houston—The Sinclair Consolidated Oil Corporation, 45 Nassau Street, New York, plans installation of electric power equipment in connection with an expansion and improvement program at its oil refining, storage and distributing plant at Sinco, on the Houston Ship Channel, entire project reported to cost over $3,000,000.

Va., Falls Church—The Common Council is said to be planning the installation of pumping machinery and auxiliary equipment, in connection with extensions and improvements in municipal waterworks, entire project to cost about $125,000.

Wis., Madison—The Madison Gas & Electric Co., Madison, is said to be planning extensions and improvements in power plant and system to cost close to $450,000.

Wis., West Bend—The Common Council has approved a bond issue of $36,000, for extensions and improvements in municipal waterworks, to include motor-driven pumping machinery and auxiliary equipment.